Access DB# 111Ø16

SEARCH REQUEST FORM

Scientific and Technical Information Center

Requester's Full Name: JOHN LEUBECKER Examiner #: 70638 Date: 12/29/03
Art Unit: 3739 Phone Number 308-0951 Serial Number: 10/072,574
Mail Box and Bldg/Room Location: CP2 4B32 Results Format Preferred (circle): PAPER DISK E-MAIL

If more than one search is submitted, please prioritize searches in order of need.

****

Please provide a detailed statement of the search topic, and describe as specifically as possible the subject matter to be searched. Include the elected species or structures, keywords, synonyms, acronyms, and registry numbers, and combine with the concept or utility of the invention. Define any terms that may have a special meaning. Give examples or relevant citations, authors, etc, if known. Please attach a copy of the cover sheet, pertinent claims, and abstract.

Title of Invention: SYSTEM + METHOD FOR GUIDING FLEXIBLE INSTRUMENT PROCEDURE

Inventors (please provide full names): KUKUK, MARKUS

Earliest Priority Filing Date: 2/7/01

***For Sequence Searches Only* Please include all pertinent information (parent, child, divisional, or issued patent numbers) along with the appropriate serial number.**

The invention relates to a method for developing a procedural method for guiding a surgical instrument to a target region inside the body. A configuration of the instrument needed to reach the target is describe by parameters of the instrument (i.e., length (depth of insertion), rotation angle, bending angle). Specific values of the parameters are used to develope instructions to obtain a particular configuration that will allow the instrument to reach the target. The instrument can be an endoscope and the procedure can be for TBNA (Transbronchial needle aspiration)

A copy of the independent claims (1 and 12) and the abstract are attached.

****

STAFF USE ONLY

Searcher: EMORY DAMRON
Searcher Phone #: 305-8587
Searcher Location: CP2 2C8
Date Searcher Picked Up: 12/29/03 3:30pm
Date Completed: 12/30/03 430pm
Searcher Prep & Review Time: 200 min
Clerical Prep Time: 0
Online Time: 300 min

Type of Search		Vendors and cost where applicable	
NA Sequence (#)		STN	
AA Sequence (#)		Dialog	✓ 2266.76
Structure (#)		Questel/Orbit	
Bibliographic	✓	Dr.Link	
Litigation		Lexis/Nexis	
Fulltext	✓	Sequence Systems	
Patent Family		WWW/Internet	✓ SCIRUS
Other		Other (specify)	

PTO-1590 (8-01)

STIC Search Report

EIC 3700

USPTO

STIC Database Tracking Number: 111016

TO: John Leubecker **Location: cp2 ~~4b32~~** 4E6 **Art Unit: 3739** **Tuesday, December 30, 2003** **Case Serial Number: 10/072574**	**From: Emory Damron** **Location: EIC 3700** **CP2-2C08** **Phone: 305-8587** **Emory.Damron@uspto.gov**

Search Notes

Dear John,

Please find below an inventor search in the bibliographic and full-text foreign patent files, as well as keyword searches in the patent and non-patent literature files, both bibliographic and full text.

References of potential pertinence have been tagged, but please review all the packets in case you like something I didn't.

In addition to searching on Dialog, I also searched Scirus.com and EPO/JPO/Derwent.

The claims in this application seem awfully broadly drawn, and it seemed wherever I looked I found art which could read on independent claims 1 and 12.

Please contact me if I can refocus or expand any aspect of this case.

Happy New Year!

Sincerely,

Emory Damron
Technical Information Specialist
EIC 3700, US Patent & Trademark Office
Phone: (703) 305-8587/ Fax: (703) 306-5915
Emory.damron@uspto.gov

sira

Search and Information Resources Administration

STIC Search Results Feedback Form

EIC 3700

Questions about the scope or the results of the search? Contact ***the EIC searcher or contact***:

John Sims, EIC 3700 Team Leader
308-4836, CP2-2C08

Voluntary Results Feedback Form

- *I am an examiner in Workgroup:* ☐ *Example: 3730*
- *Relevant prior art **found**, search results used as follows:*
  - ☐ 102 rejection
  - ☐ 103 rejection
  - ☐ Cited as being of interest.
  - ☐ Helped examiner better understand the invention.
  - ☐ Helped examiner better understand the state of the art in their technology.

  Types of relevant prior art found:
  - ☐ Foreign Patent(s)
  - ☐ Non-Patent Literature
    (journal articles, conference proceedings, new product announcements etc.)
- *Relevant prior art **not found:***
  - ☐ Results verified the lack of relevant prior art (helped determine patentability).
  - ☐ Results were not useful in determining patentability or understanding the invention.

Comments:

Drop off or send completed forms to STIC/EIC3700 CP2 2C08

sira
Search and Information Resources Administration

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Set     Items   Description
S1          2   AU=(KUKUK M? OR KUKUK, M? OR KUKUK M OR KUKUK, M OR KUKUK -
             M. OR KUKUK, M. OR KUKUK MARKUS OR KUKUK, MARKUS)
S2      55256   ENDOSCOP? OR BRONCHOSCOP? OR FLEXIBLE()INSTRUMENT? OR CATH-
             ETER? OR VIDEOSCOP?
S3          2   S1 AND S2
? show files
File 347:JAPIO Oct 1976-2003/Aug(Updated 031202)
         (c) 2003 JPO & JAPIO
File 350:Derwent WPIX 1963-2003/UD,UM &UP=200382
         (c) 2003  Thomson Derwent
```

3/5,K/1 (Item 1 from file: 350)
DIALOG(R)File 350:Derwent WPIX

015836688 **Image available**
WPI Acc No: 2003-898892/200382
XRPX Acc No: N03-717391

Flexible tube simulation method, involves determining workspace of flexible tube according to model of flexible tube and determining model of active bending behavior of tip of flexible tube

Patent Assignee: KUKUK M (KUKU-I); SIEMENS CORP RES INC (SIEI)
Inventor: **KUKUK M**
Number of Countries: 003 Number of Patents: 002
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
US 20030182091	A1	20030925	US 2002102580	A	20020320	200382	B
WO 200381351	A2	20031002	WO 2003US7170	A	20030310	200382	

Priority Applications (No Type Date): US 2002102580 A 20020320
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
US 20030182091	A1		12	G06F-017/10	
WO 200381351	A2	E		G05B-017/00	

Designated States (National): CN JP

Abstract (Basic): US 20030182091 A1

NOVELTY - The method involves representing the flexible tube in the environment according to the model. The model of the flexible tube is determined according to many of the internal and external constraints of the flexible tube. A workspace is determined according to the model of the flexible tube. A model of the active bending behavior of the tip of the flexible tube is determined.

DETAILED DESCRIPTION - INDEPENDENT CLAIMS are included for the following:

(a) a program storage device

(b) a method of modeling a workspace of a flexible tube.

USE - Used for modeling the workspace of the device.

ADVANTAGE - The method takes into account the special mechanics of the **endoscope** bending section and thus the accuracy of the model is easy to maintain.

DESCRIPTION OF DRAWING(S) - The drawing shows a flexible **endoscope**
.

Control head (101)
shaft (102)
bending section (103)
working channel. (104)
pp; 12 DwgNo 1/6

Title Terms: FLEXIBLE; TUBE; SIMULATE; METHOD; DETERMINE; FLEXIBLE; TUBE; ACCORD; MODEL; FLEXIBLE; TUBE; DETERMINE; MODEL; ACTIVE; BEND; BEHAVE; TIP; FLEXIBLE; TUBE
Derwent Class: S05; T01
International Patent Class (Main): G05B-017/00; G06F-017/10
File Segment: EPI

Inventor: **KUKUK M**

Abstract (Basic):
... The method takes into account the special mechanics of the **endoscope** bending section and thus the accuracy of the model is easy to maintain...

...The drawing shows a flexible **endoscope** .

3/5,K/2 (Item 2 from file: 350)
DIALOG(R)File 350:Derwent WPIX

015572625 **Image available**
WPI Acc No: 2003-634782/200360
XRPX Acc No: N03-504834

Flexible medical instrument handling instruction determination method e.g. for endoscope **involves parameterizing** endoscope **and determining instructions for handling** endoscope **according to** endoscope **configuration**

Patent Assignee: KUKUK M (KUKU-I)
Inventor: **KUKUK M**
Number of Countries: 001 Number of Patents: 001
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
US 20020133057	A1	20020919	US 2001266954	P	20010207	200360	B
			US 200272574	A	20020206		

Priority Applications (No Type Date): US 2001266954 P 20010207; US 200272574 A 20020206
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
US 20020133057	A1		10	A61B-001/00	Provisional application US 2001266954

Abstract (Basic): US 20020133057 A1

NOVELTY - The length, shaft rotation and bending angle of the flexible medical instrument such as **endoscope** with respect to the target lesion, are determined. The distance of the tool inserted through the **endoscope** to dock to the target is measured. The instructions for handling the **endoscope** are determined, according to the configuration of the **endoscope** .

DETAILED DESCRIPTION - An INDEPENDENT CLAIM is also included for flexible medical instrument configuration monitoring system.

USE - For determining instructions for handling flexible medical instrument e.g. **endoscope** , video or fiber optic **bronchoscope** and **catheter** used in transbronchial needle aspiration (TBNA) for **bronchoscopic** diagnosis and staging of patients with lung cancer, in operation theater.

ADVANTAGE - The handling/guidance instructions for the **flexible instrument** such as **endoscope** is provided reliably, without the use of a computer, in a cost-effective manner.

DESCRIPTION OF DRAWING(S) - The figure shows a flowchart explaining the procedure for guiding the flexible **endoscope** to target site.

pp; 10 DwgNo 5/5

Title Terms: FLEXIBLE; MEDICAL; INSTRUMENT; HANDLE; INSTRUCTION; DETERMINE; METHOD; **ENDOSCOPE** ; **ENDOSCOPE** ; DETERMINE; INSTRUCTION; HANDLE; **ENDOSCOPE** ; ACCORD; **ENDOSCOPE** ; CONFIGURATION
Derwent Class: P31; S05
International Patent Class (Main): A61B-001/00
File Segment: EPI; EngPI

Flexible medical instrument handling instruction determination method e.g. for endoscope **involves parameterizing** endoscope **and determining instructions for handling** endoscope **according to** endoscope **configuration**

Inventor: **KUKUK M**

Abstract (Basic):
... The length, shaft rotation and bending angle of the flexible medical instrument such as **endoscope** with respect to the target lesion, are determined. The distance of the tool inserted through the **endoscope** to dock to the target is measured. The instructions for handling the **endoscope** are determined, according to the configuration of the **endoscope** .
... For determining instructions for handling flexible medical instrument e.g. **endoscope** , video or fiber optic **bronchoscope** and **catheter** used in transbronchial needle aspiration (TBNA) for **bronchoscopic** diagnosis and staging of patients with lung cancer, in operation theater...

...The handling/guidance instructions for the **flexible instrument** such as **endoscope** is provided reliably, without the use of a computer, in a cost-effective manner...

...The figure shows a flowchart explaining the procedure for guiding the flexible **endoscope** to target site...
...Title Terms: **ENDOSCOPE** ;

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Set      Items   Description
S1           1   AU=(KUKUK M? OR KUKUK, M? OR KUKUK M OR KUKUK, M OR KUKUK -
              M. OR KUKUK, M. OR KUKUK MARKUS OR KUKUK, MARKUS)
S2       40212   ENDOSCOP? OR BRONCHOSCOP? OR FLEXIBLE()INSTRUMENT? OR CATH-
              ETER? OR VIDEOSCOP?
S3           1   S1 AND S2
? show files
File 348:EUROPEAN PATENTS 1978-2003/Dec W02
         (c) 2003 European Patent Office
File 349:PCT FULLTEXT 1979-2002/UB=20031225,UT=20031218
         (c) 2003 WIPO/Univentio
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3/5,AU/1 (Item 1 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

01051290
MODELING A FLEXIBLE TUBE
MODELISATION D'UN TUBE FLEXIBLE
Patent Applicant/Assignee:
SIEMENS CORPORATE RESEARCH INC, 755 College Road East, Princeton, NJ 08540, US, US (Residence), US (Nationality)
Inventor(s):
KUKUK Markus , 19 Humbert Street, Princeton, NJ 08542, US
Legal Representative:
PASCHBURG Donald B (et al) (agent), Siemens Corporation - Intellectual Property Dept., 170 Wood Ave. South, Iselin, NJ 08830, US,
Patent and Priority Information (Country, Number, Date):
Patent: WO 200381351 A2 20031002 (WO 0381351)
Application: WO 2003US7170 20030310 (PCT/WO US0307170)
Priority Application: US 2002102580 20020320
Designated States: CN JP
Main International Patent Class: G05B-017/00
Publication Language: English
Filing Language: English
Fulltext Word Count: 7567
English Abstract
A method of modeling a flexible tube in an environment includes describing the flexible tube as a chain of links and joints [600]. The method determines at least one internal constraint [601], for example, a shaft geometry [602], a shaft behavior [603], a torsional stiffness [604], a bending section geometry [605], and a bending section behavior [606]. The method determines at least one external constraint [611], for example, interactions between the tube and a physical confine [612] (e.g., as between the models of the tube and the organ), a length to a target [613], a tube workspace [614], and a workspace portion of interest [615]. From the constraints or filters, a spatial tree is grown [621]. An active bending model of the tip of the flexible tube can be implemented [622], which can, for example, model the alignment of the flexible tube relative to a target.

French Abstract
L'invention concerne un procede de modelisation d'un tube flexible dans un environnement, lequel procede consiste a decrie le tube flexible en tant que chaine de liens et d'articulations [600]. Ce procede determine au moins une contrainte interne [601], par exemple, la forme geometrique d'un arbre [602], le comportement d'un arbre [603], une rigidite en torsion [604], une forme geometrique d'une section de flexion [605] et un comportement d'une section de flexion [606]. Ce procede determine au moins une contrainte externe [611], par exemple, des interactions entre le tube et une limite physique [612] (telle que, par exemple, entre les modeles du tube et l'organe), une longueur menant a une cible [613], un espace de travail du tube [614] et une partie d'interet [615] de l'espace de travail. Un arbre spatial se developpe [621] a partir des contraintes ou des filtres. Un modele actif de flexion de la pointe du tube flexible peut etre mis en oeuvre [622], ce modele pouvant, par exemple, modeliser l'alignement du tube flexible par rapport a une cible.

Legal Status (Type, Date, Text)
Publication 20031002 A2 Without international search report and to be republished upon receipt of that report.
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Set     Items   Description
S1         31   AU=(KUKUK M? OR KUKUK, M? OR KUKUK M OR KUKUK, M OR KUKUK -
              M. OR KUKUK, M. OR KUKUK MARKUS OR KUKUK, MARKUS)
S2     954461   ENDOSCOP? OR BRONCHOSCOP? OR FLEXIBLE()INSTRUMENT? OR CATH-
              ETER? OR VIDEOSCOP?
S3         10   S1 AND S2
? show files
File   2:INSPEC 1969-2003/Dec W2
         (c) 2003 Institution of Electrical Engineers
File   5:Biosis Previews(R) 1969-2003/Dec W3
         (c) 2003 BIOSIS
File   6:NTIS 1964-2003/Dec W4
         (c) 2003 NTIS, Intl Cpyrght All Rights Res
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         (c) 2003 Inst for Sci Info
File 434:SciSearch(R) Cited Ref Sci 1974-1989/Dec
         (c) 1998 Inst for Sci Info
File 155:MEDLINE(R) 1966-2003/Dec W4
         (c) format only 2003 The Dialog Corp.
File  73:EMBASE 1974-2003/Dec W3
         (c) 2003 Elsevier Science B.V.
File  35:Dissertation Abs Online 1861-2003/Nov
         (c) 2003 ProQuest Info&Learning
File  65:Inside Conferences 1993-2003/Dec W4
         (c) 2003 BLDSC all rts. reserv.
File  94:JICST-EPlus 1985-2003/Dec W3
         (c)2003 Japan Science and Tech Corp(JST)
File 144:Pascal 1973-2003/Dec W2
         (c) 2003 INIST/CNRS
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         (c) 2003 FIZ TECHNIK
File  71:ELSEVIER BIOBASE 1994-2003/Dec W4
         (c) 2003  Elsevier Science B.V.
? pause
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3/5,K/1 (Item 1 from file: 2)
DIALOG(R)File 2:INSPEC

7731633 INSPEC Abstract Number: A2003-20-8760F-042, B2003-10-7510J-039, C2003-10-7330-356
Title: A real-time deformable model for flexible instruments **inserted into tubular structures**
Author(s): **Kukuk, M.** ; Geiger, B.
Author Affiliation: Imaging & Visualization, Siemens Corp. Res. Inc., Princeton, NJ, USA
Conference Title: Medical Image Computing and Computer-Assisted Intervention - MICCAI 2002. 5th International Conference. Proceedings, Part II (Lecture Notes in Computer Science Vol.2489) p.331-8
Editor(s): Dohi, T.; Kikinis, R,
Publisher: Springer-Verlag, Berlin, Germany
Publication Date: 2002 Country of Publication: Germany xxix+693 pp.
ISBN: 3 540 44225 1 Material Identity Number: XX-2002-03344
Conference Title: Medical Image Computing and Computer-Assisted Intervention - MICCAI 2002. 5th International Conference. Proceedings Part II
Conference Date: 25-28 Sept. 2002 Conference Location: Tokyo, Japan
Language: English Document Type: Conference Paper (PA)
Treatment: Applications (A); Theoretical (T)
Abstract: In this paper we present an approach to the problem of modelling long, **flexible instruments** , such as **endoscopes** or **catheters** . The idea is to recursively enumerate all possible shapes and subsequently filter them according to given mechanical and physical constraints. Although this brute-force approach has an exponential worst-case complexity, we show with a typical example that in case of tubular structures the empirical complexity is polynomial. We present two approximation methods that reduce this bound to a linear complexity. We have performed accuracy, runtime and robustness tests in preparation for first clinical studies. (6 Refs)
Subfile: A B C
Descriptors: biomedical optical imaging; computational complexity; **endoscopes** ; medical image processing; optical tracking; real-time systems; surgery
Identifiers: real-time deformable model; long **flexible instrument** insertion; **endoscopes** ; **catheters** ; recursive shape enumeration; shape filtering; physical constraints; mechanical constraints; brute-force approach; exponential worst-case complexity; tubular structures; polynomial complexity; approximation methods; linear complexity; robustness tests; runtime tests; accuracy tests; clinical studies
Class Codes: A8760F (Optical and laser radiation (medical uses)); A8770E (Patient diagnostic methods and instrumentation); A8770G (Patient care and treatment); B7510J (Optical and laser radiation (biomedical imaging/measurement)); B6135 (Optical, image and video signal processing); B7520 (Patient care and treatment); C7330 (Biology and medical computing) ; C4240C (Computational complexity); C5260B (Computer vision and image processing techniques)

Title: A real-time deformable model for flexible instruments **inserted into tubular structures**
Author(s): **Kukuk, M.** ; Geiger, B.
Abstract: In this paper we present an approach to the problem of modelling long, **flexible instruments** , such as **endoscopes** or **catheters** . The idea is to recursively enumerate all possible shapes and subsequently filter them according to...

...Descriptors: **endoscopes** ;
...Identifiers: long **flexible** **instrument** insertion...

... **endoscopes** ; ...

... **catheters** ;

3/5,K/2 (Item 2 from file: 2)
DIALOG(R)File 2:INSPEC

7421601 INSPEC Abstract Number: A2002-23-8760F-028, B2002-12-7510J-002, C2002-12-7330-021
Title: Modeling the internal and external constraints of a flexible endoscope **for calculating its workspace: application in transbronchial needle aspiration guidance**
Author(s): **Kukuk, M.**
Author Affiliation: Siemens Corporate Res., Princeton, NJ, USA
Journal: Proceedings of the SPIE - The International Society for Optical Engineering Conference Title: Proc. SPIE - Int. Soc. Opt. Eng. (USA) vol.4681 p.539-50
Publisher: SPIE-Int. Soc. Opt. Eng,
Publication Date: 2002 Country of Publication: USA
CODEN: PSISDG ISSN: 0277-786X
SICI: 0277-786X(2002)4681L.539:MIEC;1-8
Material Identity Number: C574-2002-234
U.S. Copyright Clearance Center Code: 0277-786X/02/$15.00
Conference Title: Medical Imaging 2002: Visualization, Image-Guided Procedures, and Display
Conference Sponsor: SPIE
Conference Date: 24-26 Feb. 2002 Conference Location: San Diego, CA, USA
Language: English Document Type: Conference Paper (PA); Journal Paper (JP)
Treatment: Theoretical (T); Experimental (X)
Abstract: In robotics, the term workspace denotes that volume of space which the end-effector of a robot can reach. Similarly we denote the workspace of a flexible **endoscope** as the volume of space that can be occupied by the entire **endoscope** . From the **endoscope** 's perspective, the workspace is determined by its internal (mechanical) constraints, as well by its external constraints, like organ geometry and gravity. We show how to calculate the workspace of a given **endoscope** under insertion into a patient specific organ model. We propose a model of an **endoscope** that takes the internal constraints into account. We also propose an algorithm which simulates the insertion of an **endoscope** into an organ. This algorithm calculates the workspace by recursively building a spatial tree whose growth is constrained by a series of filter functions. As Kukuk et al. showed, knowing a real **endoscope** 's workspace can be used to significantly increase the success rate of a blind biopsy. We have built an experimental setup (lung phantom) that allows us to assess the accuracy of our model by comparing it to a real **endoscope** . (6 Refs)
Subfile: A B C
Descriptors: algorithm theory; biomedical equipment; biomedical imaging; lung; patient diagnosis; physiological models; surgery
Identifiers: internal constraints; external constraints; flexible **endoscope** ; patient specific organ model; algorithm; spatial tree; filter functions; real **endoscope** 's workspace; blind biopsy; modeling; experimental setup; lung phantom; model; transbronchial needle aspiration guidance; robotics; end-effector; entire **endoscope** ; organ geometry;

gravity
Class Codes: A8760F (Optical and laser radiation (medical uses)); A8770G (Patient care and treatment); A8710 (General, theoretical, and mathematical biophysics); A8770E (Patient diagnostic methods and instrumentation); B7510J (Optical and laser radiation (biomedical imaging/measurement)); B7520 (Patient care and treatment); C7330 (Biology and medical computing); C4240 (Programming and algorithm theory)

Title: Modeling the internal and external constraints of a flexible endoscope **for calculating its workspace: application in transbronchial needle aspiration guidance**
Author(s): **Kukuk, M.**
...Abstract: end-effector of a robot can reach. Similarly we denote the workspace of a flexible **endoscope** as the volume of space that can be occupied by the entire **endoscope** . From the **endoscope** 's perspective, the workspace is determined by its internal (mechanical) constraints, as well by its...

... like organ geometry and gravity. We show how to calculate the workspace of a given **endoscope** under insertion into a patient specific organ model. We propose a model of an **endoscope** that takes the internal constraints into account. We also propose an algorithm which simulates the insertion of an **endoscope** into an organ. This algorithm calculates the workspace by recursively building a spatial tree whose...

... constrained by a series of filter functions. As Kukuk et al. showed, knowing a real **endoscope** 's workspace can be used to significantly increase the success rate of a blind biopsy...

...allows us to assess the accuracy of our model by comparing it to a real **endoscope** .
...Identifiers: flexible **endoscope** ; ...

...real **endoscope** 's workspace...

...entire **endoscope** ;

3/5,K/3 (Item 1 from file: 8)
DIALOG(R)File 8:Ei Compendex(R)

06121491 E.I. No: EIP02367069094
Title: Modeling the internal and external constraints of a flexible endoscope **for calculating its workspace: Application in transbronchial needle aspiration guidance**
Author: **Kukuk, Markus**
Corporate Source: Siemens Corporate Research, Princeton, NJ, United States
Conference Title: Medical Imaging 2002 Visualization, Image-Guided Procedures and Display
Conference Location: San Diego, CA, United States Conference Date: 20020224-20020226
Sponsor: SPIE
E.I. Conference No.: 59492
Source: Proceedings of SPIE - The International Society for Optical Engineering v 4681 2002. p 539-550
Publication Year: 2002
CODEN: PSISDG ISSN: 0277-786X

Language: English
Document Type: CA; (Conference Article)   Treatment: T; (Theoretical)
Journal Announcement: 0209W2

Abstract: In robotics, the term "workspace" denotes that volume of space which the end-effector of a robot can reach. Similarly we denote the workspace of a flexible **endoscope** as the volume of space that can be occupied by the entire **endoscope** . From the **endoscope** 's perspective, the workspace is determined by its internal (mechanical) constraints, as well by it's external constraints, like organ geometry and gravity. In this paper we show how to calculate the workspace of a given **endoscope** under insertion into a patient specific organ model. We propose a model of an **endoscope** that takes the internal constraints into account. We also propose an algorithm which simulates the insertion of an **endoscope** into an organ. This algorithm calculates the workspace by recursively building a spatial tree whose growth is constrained by a series of filter functions. As Kukuk et. al.**1 showed, knowing a real **endoscope** 's workspace can be used to significantly increase the success rate of a "blind" biopsy. We have built an experimental setup (lung phantom) that allows us to assess the accuracy of our model by comparing it to a real **endoscope** . 6 Refs.

Descriptors: **Endoscopy** ; Biological organs; Biopsy; Stiffness; Parameter estimation; Algorithms; Computer simulation
Identifiers: Transbronchial needle aspirations (TBNA)
Classification Codes:
461.6 (Medicine); 461.2 (Biological Materials); 723.5 (Computer Applications)
461 (Bioengineering); 921 (Applied Mathematics); 723 (Computer Software, Data Handling & Applications)
46 (BIOENGINEERING); 92 (ENGINEERING MATHEMATICS); 72 (COMPUTERS & DATA PROCESSING)

Title: Modeling the internal and external constraints of a flexible endoscope **for calculating its workspace: Application in transbronchial needle aspiration guidance**
Author: **Kukuk, Markus**
...Abstract: end-effector of a robot can reach. Similarly we denote the workspace of a flexible **endoscope** as the volume of space that can be occupied by the entire **endoscope** . From the **endoscope** 's perspective, the workspace is determined by its internal (mechanical) constraints, as well by it...

...and gravity. In this paper we show how to calculate the workspace of a given **endoscope** under insertion into a patient specific organ model. We propose a model of an **endoscope** that takes the internal constraints into account. We also propose an algorithm which simulates the insertion of an **endoscope** into an organ. This algorithm calculates the workspace by recursively building a spatial tree whose...

...by a series of filter functions. As Kukuk et. al.**1 showed, knowing a real **endoscope** 's workspace can be used to significantly increase the success rate of a "blind" biopsy...

...allows us to assess the accuracy of our model by comparing it to a real **endoscope** . 6 Refs.
Descriptors: **Endoscopy** ; Biological organs; Biopsy; Stiffness; Parameter estimation; Algorithms; Computer simulation

3/5,K/4 (Item 1 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

09024404 20318106 PMID: 10977533

Registration of real and virtual endoscopy **--a model and image based approach.**

Kukuk M ; Geiger B

SIEMENS Corporate Research, Princeton, NJ, USA.

Studies in health technology and informatics (NETHERLANDS) 2000, 70 p168-74, ISSN 0926-9630 Journal Code: 9214582

Document type: Journal Article

Languages: ENGLISH

Main Citation Owner: NLM

Record type: Completed

Subfile: HEALTH TECHNOLOGY ASSESSMENT

This paper describes work in progress to integrate real and virtual **endoscopy** and to apply virtual **endoscopy** to the intra-operative guidance of **endoscopic** procedures. We propose a method for real-time tracking of the **endoscope** 's shape and position. Our approach makes use of a simple and small external device, a computer model of a flexible **endoscope** and an image-based registration technique.

Tags: Human; Support, Non-U.S. Gov't

Descriptors: Computer Simulation; * **Endoscopy** ; *Image Processing, Computer-Assisted; *User-Computer Interface; Phantoms, Imaging

Record Date Created: 20000815

Record Date Completed: 20000815

Registration of real and virtual endoscopy **--a model and image based approach.**

Kukuk M ; Geiger B

This paper describes work in progress to integrate real and virtual **endoscopy** and to apply virtual **endoscopy** to the intra-operative guidance of **endoscopic** procedures. We propose a method for real-time tracking of the **endoscope** 's shape and position. Our approach makes use of a simple and small external device, a computer model of a flexible **endoscope** and an image-based registration technique.

Descriptors: Computer Simulation; * **Endoscopy** ; *Image Processing, Computer-Assisted; *User-Computer Interface

3/5,K/5 (Item 1 from file: 65)

DIALOG(R)File 65:Inside Conferences

04315552 INSIDE CONFERENCE ITEM ID: CN045223139

A Real-Time Deformable Model for Flexible Instruments **Inserted into Tubular Structures**

Kukuk, M. ; Geiger, B.

CONFERENCE: Medical image computing and computer-assisted intervention-International conference; 5th

LECTURE NOTES IN COMPUTER SCIENCE, 2002; (NO) 2489 P: 331-338

Berlin, New York, Springer, c2002

ISSN: 0302-9743 ISBN: 3540442251

LANGUAGE: English DOCUMENT TYPE: Conference Selected papers

CONFERENCE EDITOR(S): Dohi, T.; Kikinis, R.

CONFERENCE LOCATION: Tokyo 2002; Sep (200209) (200209)

BRITISH LIBRARY ITEM LOCATION: 5180.185000

NOTE:

Also known as MICCAI 2002; Includes bibliographical references and index

DESCRIPTORS: MICCAI; medical image computing; medical image computer;

assisted intervention

A Real-Time Deformable Model for Flexible Instruments **Inserted into Tubular Structures**
Kukuk, M. ; Geiger, B.

3/5,K/6 (Item 2 from file: 65)
DIALOG(R)File 65:Inside Conferences

04311185 INSIDE CONFERENCE ITEM ID: CN045179461
A Real-Time Deformable Model for Flexible Instruments **Inserted into Tubular Structures**
Kukuk, M. ; Geiger, B.
CONFERENCE: Medical image computing and computer-assisted intervention-
International conference; 5th
LECTURE NOTES IN COMPUTER SCIENCE, 2002; (NO) 2489 P: 331-338
Berlin, New York, Springer, c2002
ISSN: 0302-9743 ISBN: 3540442251
LANGUAGE: English DOCUMENT TYPE: Conference Selected papers
CONFERENCE EDITOR(S): Dohi, T.; Kikinis, R.
CONFERENCE LOCATION: Tokyo 2002; Sep (200209) (200209)

BRITISH LIBRARY ITEM LOCATION: 5180.185000
NOTE:
Also known as MICCAI 2002
DESCRIPTORS: MICCAI; medical image computing; medical image computer; assisted intervention

A Real-Time Deformable Model for Flexible Instruments **Inserted into Tubular Structures**
Kukuk, M. ; Geiger, B.

3/5,K/7 (Item 3 from file: 65)
DIALOG(R)File 65:Inside Conferences

04223554 INSIDE CONFERENCE ITEM ID: CN044303152
Modeling the internal and external constraints of a flexible endoscope **for calculating its workspace: application in transbronchial** needle **aspiration guidance (4681-61)**
Kukuk, M.
CONFERENCE: Visualization image guided procedures and display-Conference
PROCEEDINGS-SPIE THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING, 2002 ; VOL 4681 P: 539-550
SPIE, 2002
ISBN: 081944426x
LANGUAGE: English DOCUMENT TYPE: Conference Papers
CONFERENCE EDITOR(S): Seong K, M.
CONFERENCE SPONSOR: American Association of Physicists in Medicine
SPIE
CONFERENCE LOCATION: San Diego, CA 2002; Feb (200202) (200202)

BRITISH LIBRARY ITEM LOCATION: 6823.100000
DESCRIPTORS: visualization; medical imaging; AAPM; SPIE; image guided procedures

Modeling the internal and external constraints of a flexible endoscope

for calculating its workspace: application in transbronchial needle aspiration guidance (4681-61)
Kukuk, M.

3/5,K/8 **(Item 4 from file: 65)**
DIALOG(R)File 65:Inside Conferences

03348569 INSIDE CONFERENCE ITEM ID: CN035380772
Registration of Real and Virtual Endoscopy **-A Model and Image Based Approach**
Kukuk, M. ; Geiger, B.
CONFERENCE: Medicine meets virtual reality 2000; envisioning healing interactive technology and the patient-practitioner dialogue-Conference
STUDIES IN HEALTH TECHNOLOGY AND INFORMATICS, 2000; VOL 70 P: 168-174
Amsterdam, Tokyo, IOS Press, Ohmsha, 2000
ISSN: 0926-9630 ISBN: 1586030140; 4274903354
LANGUAGE: English DOCUMENT TYPE: Conference Papers
CONFERENCE EDITOR(S): Westwood, J. D. 2000

BRITISH LIBRARY ITEM LOCATION: 8490.628200
NOTE:
Also known as MMVR2000
DESCRIPTORS: MMVR; virtual reality; envisioning healing; interactive technology ; patient-practitioner dialogue; medicine

Registration of Real and Virtual Endoscopy **-A Model and Image Based Approach**
Kukuk, M. ; Geiger, B.

3/5,K/9 **(Item 1 from file: 95)**
DIALOG(R)File 95:TEME-Technology & Management

01702416 20021108049
A real-time deformable model for flexible instruments **inserted into tubular structures**
(Ein deformierbares Echtzeit-Modell fuer **flexible** **Instrumente** , die in tubulaere Strukturen eingefuehrt werden)
Kukuk, M ; Geiger, B
Siemens Corporate Res., Princeton, USA; Univ. Dortmund, D
MICCAI 2002, Medical Image Computing and Computer-Assisted Intervention, 5th Internat. Conf., Proc., Part II, Tokyo, J, Sep 25-28, 2002Lecture Notes in Computer Science, v2489, n7, pp331-338, 2002
Document type: Conference paper Language: English
Record type: Abstract
ISBN: 3-540-44225-1
ISSN: 0302-9743

ABSTRACT:
In the paper the authors present an approach to the problem of modelling long, **flexible** **instruments** , such as **endoscopes** or **catheters** . The idea is to recursively enumerate all possible shapes and subsequently filter them to given mechanical and physical constraints. Although this brute-force approach has an exponential worst-case complexity, it is shown with a typical example that in case of tubular structures the empirical complexity is polynomial. The authors present two approximation methods that reduce this bound to a linear complexity. They have performed

accuracy, runtime and robustness tests in preparation for first clinical studies.

DESCRIPTORS: BIOMEDICAL DEVICES; REAL TIME SYSTEM; COMPUTER MODELLING; **CATHETERS** ; APPROXIMATION METHOD; ELECTRIC WAVE FILTERS
IDENTIFIERS: TUBULAERE STRUKTUR; flexibles Modell; Approximation; medizinisches Geraet

A real-time deformable model for flexible instruments **inserted into tubular structures**
(Ein deformierbares Echtzeit-Modell fuer **flexible Instrumente** , die in tubulaere Strukturen eingefuehrt werden)
Kukuk, M ; Geiger, B

ABSTRACT:
In the paper the authors present an approach to the problem of modelling long, **flexible instruments** , such as **endoscopes** or **catheters** . The idea is to recursively enumerate all possible shapes and subsequently filter them to given...
DESCRIPTORS: BIOMEDICAL DEVICES; REAL TIME SYSTEM; COMPUTER MODELLING; **CATHETERS** ; APPROXIMATION METHOD; ELECTRIC WAVE FILTERS

3/5,K/10 (Item 2 from file: 95)
DIALOG(R)File 95:TEME-Technology & Management

01606384 20020201158
TBNA-protocols. Guiding TransBronchial Needle Aspirations without a computer in the operating room
(TBNA-Protokolle. Fuehrung von transbronchialen Nadelaspirationen ohne Computer im Operationssaal)
Kukuk, M ; Geiger, B; Mueller, H
Siemens Corporate Res., Princeton, USA; Univ. Dortmund, D
MICCAI 2001, Medical Image Computing and Computer-Assisted Intervention, 4th Internat. Conf., Proc., Utrecht, NL, Oct 14-17, 2001Lecture Notes in Computer Science, v2208, n3/4, pp997-1006, 2001
Document type: Conference paper Language: English
Record type: Abstract
ISBN: 3-540-42697-3
ISSN: 0302-9743

ABSTRACT:
The authors attempt to maximize the success probability for ''blind'' biopsies by preoperatively estimating four parameters. These parameters well-define the procedure, given that the **bronchoscope** resides ''somewhere'' inside the target branch of the tracheobronchial tree. The calculations are based on a patient-specific lung model (CT scan) and a digital model of a flexible **bronchoscope** . Using both models, the authors simulate the biopsy and derive frequency distributions for each parameter. Based on these distributions, they choose several parameter sets that together maximize the success probability. The parameters are provided to the surgeon in form of detailed step-by-step instructions (protocol) of how to handle the **bronchoscope** . To control the parameters in the operating room (OR) passive controls were used. First lung phantom experiments show that the authors could hit in worst-case 12 mm targets (average-case: 5 mm) with three aspirations.

DESCRIPTORS: COMPUTER MODELLING; MINIMALLY INVASIVE SURGERY; LUNG; COMPUTED TOMOGRAPHY

IDENTIFIERS: TBNA PROTOKOLL; LUNGENKREBS; Bronchoskopie; Lungenkrebs; Nadelbiopsie; TBNA-Protokoll

Kukuk, M ; Geiger, B; Mueller, H

ABSTRACT:
...biopsies by preoperatively estimating four parameters. These parameters well-define the procedure, given that the **bronchoscope** resides ''somewhere'' inside the target branch of the tracheobronchial tree. The calculations are based on a patient-specific lung model (CT scan) and a digital model of a flexible **bronchoscope** . Using both models, the authors simulate the biopsy and derive frequency distributions for each parameter ...

...surgeon in form of detailed step-by-step instructions (protocol) of how to handle the **bronchoscope** . To control the parameters in the operating room (OR) passive controls were used. First lung...

```
Set      Items   Description
S1          1    AU=(KUKUK M? OR KUKUK, M? OR KUKUK M OR KUKUK, M OR KUKUK -
               M. OR KUKUK, M. OR KUKUK MARKUS OR KUKUK, MARKUS)
S2       76452   ENDOSCOP? OR BRONCHOSCOP? OR FLEXIBLE()INSTRUMENT? OR CATH-
               ETER? OR VIDEOSCOP?
S3          0    S1 AND S2
? show files
File  16:Gale Group PROMT(R) 1990-2003/Dec 29
         (c) 2003 The Gale Group
File 160:Gale Group PROMT(R) 1972-1989
         (c) 1999 The Gale Group
File 148:Gale Group Trade & Industry DB 1976-2003/Dec 24
         (c)2003 The Gale Group
File 621:Gale Group New Prod.Annou.(R) 1985-2003/Dec 24
         (c) 2003 The Gale Group
File 441:ESPICOM Pharm&Med DEVICE NEWS 2003/Dec W3
         (c) 2003 ESPICOM Bus.Intell.
File 444:New England Journal of Med. 1985-2003/Dec W4
         (c) 2003 Mass. Med. Soc.
File 149:TGG Health&Wellness DB(SM) 1976-2003/Dec W1
         (c) 2003 The Gale Group
File 369:New Scientist 1994-2003/Dec W2
         (c) 2003 Reed Business Information Ltd.
File 370:Science 1996-1999/Jul W3
         (c) 1999 AAAS
File  98:General Sci Abs/Full-Text 1984-2003/Nov
         (c) 2003 The HW Wilson Co.
File 135:NewsRx Weekly Reports 1995-2003/Dec W3
         (c) 2003 NewsRx
File 743:(New Jersey)The Record 1989-2003/Dec 26
         (c) 2003 No.Jersey Media G Inc
```

1/5,K/1 (Item 1 from file: 148)

DIALOG(R)File 148:Gale Group Trade & Industry DB

07595205 SUPPLIER NUMBER: 15933615 (USE FORMAT 7 OR 9 FOR FULL TEXT)

Bioremediation: bacterial surf 'n' turf. (how municipalities are using bacteria to decontaminate water and soil) (Cover Story)

Kukuk, Mike

American City & County, v109, n11, p40(6)
Oct, 1994
DOCUMENT TYPE: Cover Story ISSN: 0149-337X LANGUAGE: ENGLISH
RECORD TYPE: FULLTEXT; ABSTRACT
WORD COUNT: 2001 LINE COUNT: 00171

ABSTRACT: Bioremediation is an innovative process for controlling pollution in an environmentally sensitive and cost-effective way. Water and soil contaminants are controlled by allowing microbes to thrive where they can break down waste substances and convert them to other chemicals.

SPECIAL FEATURES: illustration; photograph
INDUSTRY CODES/NAMES: REG Business, Regional
DESCRIPTORS: Bioremediation--Environmental aspects; Water pollution control industry--Innovations; Soil disinfection--Innovations
PRODUCT/INDUSTRY NAMES: 4951000 (Water Pollution); 4953000 (Refuse Systems)
SIC CODES: 4953 Refuse systems
FILE SEGMENT: MI File 47

Kukuk, Mike

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Set     Items   Description
S1    8289418   METHOD? OR SYSTEM? OR PROCEDURE? OR PROCESS?
S2      29764   VIDEOSCOP? OR BRONCOSCOP? OR BRONCHOSCOP? OR BRONCHISCOP? -
             OR ENDOSCOP? OR FLEXIBLE()(TOOL? OR INSTRUMENT? OR CYLINDER?)
S3          0   DC=(E7.230.220? OR E7.858.240?)
S4    2147918   INSTRUCTION? OR DIRECTION? OR NAVIGATION?
S5      28049   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
             CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
             PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(MODEL? OR PLA-
             N? OR PATH? OR GEOMETR? OR MAP OR MAPPING OR MAPS)
S6      39446   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
             CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
             PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(IMAGE? ? OR I-
             MAGING OR ORIENTATION? OR CONFIGURATION? OR TRAJECT?)
S7       2785   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
             CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
             PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(CT OR CAT OR -
             TOMOGRAPH? OR MRI OR ULTRASO? OR MAGNETIC?()RESONAN?)
S8       1043   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
             CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
             PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(2()D OR 2DIME-
             NSION? OR 2()DIMENSION? OR TWODIMENS? OR TWO()DIMENSION?)
S9       2944   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
             CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
             PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(3()D OR 3DIME-
             NSION? OR 3()DIMENSION? OR THREEDIMENS? OR THREE()DIM...
S10      4059   TBNA OR TRANSBRON?()NEEDLE?()ASPIRAT? OR BIOPS?
S11   1591473   CHARACTERISTIC? OR PARAMETER? OR ROTATION?
S12   1914263   DIAMETER? OR LENGTH? OR DISTANCE? OR DEPTH?
S13   1452264   BEND? OR DEFLECT? OR CURV? OR ANGLE? ?
S14    116114   (ANATOM? OR BODY OR BODILY)(2N)(LANDMARK? OR SITE? OR TARG-
             ET? OR STRUCTURE? OR PART?) OR CARINA?
S15     53567   LESION? OR TUMOR? OR TUMOUR? OR TRACHEOBRONC?()TREE?
S16    885157   GUIDE? ? OR GUIDING OR MANIPULAT?
S17   4258187   HANDLE? ? OR HANDLING OR INSERT? OR OPERAT?
S18    233251   IC=A61B?
S19     11977   S1 AND S2:S3
S20      1761   S19 AND S4:S9
S21        29   S20 AND S10
S22       913   S20 AND S11:S15
S23       272   S22 AND S16:S17(5N)S2:S3
S24        76   S23 AND S4:S9(5N)S16:S17
S25       273   S22:S23 AND S4:S9(5N)S11:S15
S26        25   S24 AND S25
S27       764   (S22 OR S23 OR S25 OR S24) AND S18
S28        52   S21 OR S26
S29        30   S28 AND S27
S30        52   S28:S29
S31        43   S30 AND PY<2002
S32        43   IDPAT (sorted in duplicate/non-duplicate order)
? show files
File 347:JAPIO Oct 1976-2003/Aug(Updated 031202)
         (c) 2003 JPO & JAPIO
File 350:Derwent WPIX 1963-2003/UD,UM &UP=200382
         (c) 2003  Thomson Derwent
```

32/5,K/1 (Item 1 from file: 350)
DIALOG(R)File 350:Derwent WPIX

014325845 **Image available**
WPI Acc No: 2002-146547/ **200219**
Related WPI Acc No: 1999-058597; 2000-364359; 2001-579330; 2001-656162; 2002-204445; 2002-236496; 2002-641468
XRPX Acc No: N02-111024

Steerable catheter for endoscopic **treatment, uses computer control for position of catheter inside body of patient, by varying power applied to external electromagnet**

Patent Assignee: LEMELSON J (LEME-I)
Inventor: LEMELSON J
Number of Countries: 001 Number of Patents: 001
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
US 6233474	B1	20010515	US 96743794	A	19961105	200219	B
			US 98149730	A	19980908		

Priority Applications (No Type Date): US 96743794 A 19961105; US 98149730 A 19980908
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
US 6233474	B1		15	A61B-017/00	Cont of application US 96743794
					Cont of patent US 5845646

Abstract (Basic): US 6233474 B1

NOVELTY - Location sensor senses relative positions of catheter and anatomical regions and outputs coded signals representing scanned regions, to a computer. The computer controls position of catheter, by varying power applied to electromagnet positioned external.

USE - For positioning catheter, laproscopes, **endoscopes** , surgical tools, tissue manipulators, devices for in-vivo administration of solid and liquid drugs, angioplasty devices, **biopsy** and sampling devices, RF, thermal, microwave, laser energy or ionizing radiation delivery devices, etc.

ADVANTAGE - Precise control over the location of catheters, laproscopes, etc., is enabled, as real-time interactive computer control is provided. Steerable catheters have minimal or no interior steering equipment, thus minimizing the size and also the trauma and unwanted tissue damage.

DESCRIPTION OF DRAWING(S) - The figure shows the **patient orientation system** optionally used to control the position of **endoscopic** device within the patient body.

Scanning **system** (25)

pp; 15 DwgNo 2/17

Title Terms: STEER; CATHETER; **ENDOSCOPE** ; TREAT; COMPUTER; CONTROL; POSITION; CATHETER; BODY; PATIENT; VARY; POWER; APPLY; EXTERNAL; ELECTROMAGNET
Derwent Class: P31; S05; T01; W04
International Patent Class (Main): A61B-017/00
File Segment: EPI; EngPI

Steerable catheter for endoscopic **treatment, uses computer control for position of catheter inside body of patient, by varying power...**

Abstract (Basic):
... For positioning catheter, laproscopes, **endoscopes** , surgical tools, tissue manipulators, devices for in-vivo administration of solid and liquid drugs, angioplasty devices, **biopsy** and sampling devices,

RF, thermal, microwave, laser energy or ionizing radiation delivery devices, etc...

...The figure shows the **patient orientation system** optionally used to control the position of **endoscopic** device within the patient body...

...Scanning **system** (25...
...Title Terms: **ENDOSCOPE** ;

32/5,K/4 (Item 4 from file: 350)
DIALOG(R)File 350:Derwent WPIX

014248284 **Image available**
WPI Acc No: 2002-068984/ **200210**
XRPX Acc No: N02-050998
Image processor **, has display section on which graphic model of needle is superimposed with the three-dimensional** endoscope **image**
Patent Assignee: TOSHIBA KK (TOKE)
Number of Countries: 001 Number of Patents: 001
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
JP 2001070248	A	20010321	JP 99248848	A	19990902	200210	B

Priority Applications (No Type Date): JP 99248848 A 19990902
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
JP 2001070248	A		7	A61B-005/00	

Abstract (Basic): JP 2001070248 A
NOVELTY - An **endoscope** image producing section (21) generates a three-dimensional **endoscope** image of the end position of a **biopsy** needle as observed from a **predetermined** position. The graphic **model** of needle produced by a graphic model producing section (16) is then superimposed and subsequently displayed with the three-dimensional **endoscope** image on a display section (10).
USE - For producing and subsequently displaying the operation assistance information on a **biopsy** needle.
ADVANTAGE - Enables operator to properly position **biopsy** needle to the organ requiring treatment or diagnosis.
DESCRIPTION OF DRAWING(S) - The figure shows the component block diagram of the image **processor** . (Drawing includes non-English language text)
Display section (10)
Graphic model producing section (16)
Endoscope image producing section (21)
pp; 7 DwgNo 1/4
Title Terms: IMAGE; **PROCESSOR** ; DISPLAY; SECTION; GRAPHIC; MODEL; NEEDLE; SUPERIMPOSED; THREE-DIMENSIONAL; **ENDOSCOPE** ; IMAGE
Derwent Class: P31; S05
International Patent Class (Main): A61B-005/00
International Patent Class (Additional): A61B-005/055; A61B-010/00
File Segment: EPI; EngPI
Image processor **, has display section on which graphic model of needle is superimposed with the three-dimensional** endoscope **image**
Abstract (Basic):
... An **endoscope** image producing section (21) generates a three-dimensional **endoscope** image of the end position of a **biopsy** needle as observed from a **predetermined** position. The graphic **model** of needle produced by a graphic model producing section (16) is then superimposed and subsequently displayed with the three-dimensional **endoscope** image on a display section (10).
... For producing and subsequently displaying the operation assistance information on a **biopsy** needle...

...Enables operator to properly position **biopsy** needle to the organ requiring treatment or diagnosis...

...The figure shows the component block diagram of the image **processor** .

(Drawing includes non-English language text...

... **Endoscope** image producing section (21
...Title Terms: **PROCESSOR** ;

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開2001－70248

(P2001－70248A)

(43)公開日　平成13年３月21日(2001.3.21)

(51)Int.Cl.7	識別記号	ＦＩ		テーマコード*(参考)
Ａ６１Ｂ　5/00		Ａ６１Ｂ　5/00	Ｄ	４Ｃ０９６
5/055		10/00	１０３Ｂ	
10/00	１０３	5/05	３９０	

審査請求　未請求　請求項の数10　ＯＬ　（全　７　頁）

(21)出願番号　特願平11－248848

(22)出願日　平成11年９月２日(1999.9.2)

(71)出願人　000003078
株式会社東芝
神奈川県川崎市幸区堀川町72番地

(72)発明者　福永　智久
栃木県大田原市下石上1385番の１　株式会社東芝那須工場内

(74)代理人　100058479
弁理士　鈴江　武彦　（外６名）

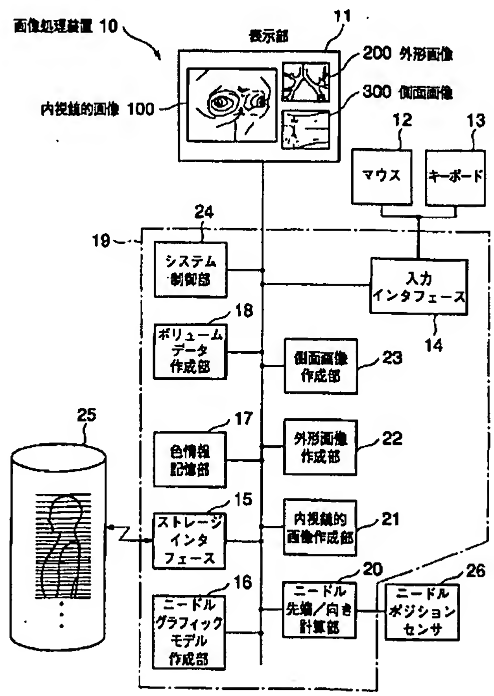
Ｆターム(参考)　4C096 AB36 AD15 DC31 DC36 DC40
DD11 DD20

(54)【発明の名称】　画像処理装置

(57)【要約】

【課題】本発明の目的は、バイオプシーニードルの操作支援情報を作成し表示する画像処理装置において、バイオプシーニードルの針先からその前方にある臓器等までの距離感をより分かり易く提供することにある。

【解決手段】本発明による画像処理装置は、バイオプシーニードルの操作支援情報として、ニードルの先端位置より所定距離後方の位置の視点から見た内視鏡的な３次元画像を内視鏡的画像作成部２１により対象部位に関するボリュームデータから作成し、ニードルグラフィックモデル作成部１６で作成されたニードルのグラフィックモデルを重畳して表示する。



32/5,K/5 (Item 5 from file: 350)
DIALOG(R)File 350:Derwent WPIX

014098003 **Image available**
WPI Acc No: 2001-582217/ **200165**
XRPX Acc No: N01-433735
Surgical patient image **display** method **for guiding physicians, involves displaying slices of registered image, based on view point selected with reference to patient**
Patent Assignee: INSIGHTEC-IMAGE GUIDED TREATMENT LTD (INSI-N)
Inventor: FREUNDLICH D; MODAN Y; YAGEL R; ZADICARIO E
Number of Countries: 094 Number of Patents: 003
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
WO 200165490	A2	20010907	WO 2001IL183	A	20010227	200165	B
AU 200135951	A	20010912	AU 200135951	A	20010227	200204	
EP 1259940	A2	20021127	EP 2001908094	A	20010227	200302	
			WO 2001IL183	A	20010227		

Priority Applications (No Type Date): US 2000515624 A 20000229
Patent Details:
Patent No Kind Lan Pg Main IPC Filing Notes
WO 200165490 A2 E 34 G06T-015/00
Designated States (National): AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG UZ VN YU ZA ZW
Designated States (Regional): AT BE CH CY DE DK EA ES FI FR GB GH GM GR IE IT KE LS LU MC MW MZ NL OA PT SD SE SL SZ TR TZ UG ZW
AU 200135951 A G06T-015/00 Based on patent WO 200165490
EP 1259940 A2 E G06T-015/00 Based on patent WO 200165490
Designated States (Regional): AL AT BE CH CY DE DK ES FI FR GB GR IE IT LI LT LU LV MC MK NL PT RO SE SI TR

Abstract (Basic): WO 200165490 A2
NOVELTY - An **image** of a surgical **patient** (10) is registered. A slice of registered image is displayed, based on a view point selected with reference to the patient.
DETAILED DESCRIPTION - INDEPENDENT CLAIMS are also included for the following:
(a) Selected image slice display **system** ;
(b) Input device
USE - For guiding physicians using catheter, **endoscope** or a **biopsy** needle during surgery.
ADVANTAGE - Interactively selects and displays slices of three-dimensional digital **image** of surgical **patient** with reference to patient.
DESCRIPTION OF DRAWING(S) - The figure shows the selection **process** of slices of the image for display.
Surgical patient (10)
pp; 34 DwgNo 2b/5
Title Terms: SURGICAL; PATIENT; IMAGE; DISPLAY; **METHOD** ; GUIDE; DISPLAY; SLICE; REGISTER; IMAGE; BASED; VIEW; POINT; SELECT; REFERENCE; PATIENT
Derwent Class: S05; T01
International Patent Class (Main): G06T-015/00
File Segment: EPI
Surgical patient image **display** method **for guiding physicians, involves displaying slices of registered image, based on view point selected with...**

Abstract (Basic):

... An **image** of a surgical **patient** (10) is registered. A slice of registered image is displayed, based on a view point...

... a) Selected image slice display **system** ;
(...

...For guiding physicians using catheter, **endoscope** or a **biopsy** needle during surgery...

...Interactively selects and displays slices of three-dimensional digital **image** of surgical **patient** with reference to patient...

...The figure shows the selection **process** of slices of the image for display

...Title Terms: **METHOD** ;

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 September 2001 (07.09.2001)

PCT

(10) International Publication Number
WO 01/65490 A2

(51) International Patent Classification[7]: G06T 15/00

(21) International Application Number: PCT/IL01/00183

(22) International Filing Date: 27 February 2001 (27.02.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/515,624 29 February 2000 (29.02.2000) US

(71) Applicant: **INSIGHTEC-IMAGE GUIDED TREATMENT LTD.** [IL/IL]; P.O. Box 2059, 39120 Tirat Hacarmel (IL).

(72) Inventors: **ZADICARIO, Eyal**; 4 Refidim Street, 69982 Tel Aviv (IL). **YAGEL, Roni**; 8 Nahal Ha'besor Street, 71700 Modi'in (IL). **FREUNDLICH, David**; 4a Bnei Brith Street, 34752 Haifa (IL). **MODAN, Yoav**; 25 Hankin Road, 32762 Haifa (IL).

(74) Agent: **G. E. EHRLICH (1995) LTD.**; 28 Bezalel Street, 52521 Ramat Gan (IL).

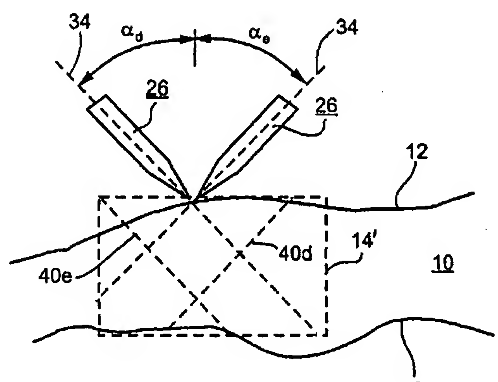
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** METHOD AND SYSTEM FOR SELECTING AND DISPLAYING A PORTION OF AN IMAGE OF A BODY



(57) **Abstract:** A method and system for displaying an image volume of a body such as the body of a surgical patient. The system of the present invention includes a memory for storing the image volume, a monitor for displaying the image volume, a pointer for selecting portions of the image volume to display with reference to the body, a mechanism for determining the position and orientation of the pointer, and a processor for overall control. The image volume is registered with the body. A portion, such as a slice, of the image volume is defined by a viewpoint that is in turn defined by positioning and orienting the pointer relative to the body. For example, the viewpoint may be defined by a target point on the body and by the orientation of the pointer. The tip of the pointer is pointed at the target point, or is placed in contact with the target point, and the pointer is pivoted. A slice of the image volume is displayed in accordance with this viewpoint. Registration of the image volume with the body is facilitated by using the pointer to sample the coordinates of points on the surface of the body. Alternatively, a suitably equipped pointer is used to sample the coordinates of points within the body, for example by ultrasound echolocation. Preferably, the pointer also is used for overall processor control.

WO 01/65490 A2

32/5,K/9 (Item 9 from file: 350)
DIALOG(R)File 350:Derwent WPIX

013483002 **Image available**
WPI Acc No: 2000-654945/ **200063**
XRPX Acc No: N00-485362

Fractional process **simulator with remote apparatus for multi-location training of medical teams has remote stations interlinked, communicating feedback information**

Patent Assignee: HON D C (HOND-I)
Inventor: HON D C
Number of Countries: 001 Number of Patents: 001
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
US 6074213	A	20000613	US 98134945	A	19980817	200063	B

Priority Applications (No Type Date): US 98134945 A 19980817
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
US 6074213	A		19	G09B-023/28	

Abstract (Basic): US 6074213 A

NOVELTY - Fractional **process** simulator involves the members being located in different places, or stations, as they train together using apparatus in coordinated fashion in relation to numerical data, or **virtual** , non-physical **model** without input from a live instructor.

DETAILED DESCRIPTION - Each station (47,48,49,50) provides a differentiated input with a number of differentiated devices, and receives differentiated feedback from the model to each individual station in representations which are visual, tactile, aural. and/or olfactory in their display, depending on the feedback required by each individual station.

USE - This invention relates to a simulator for training medical students and personnel. The training can include the use of any of the list of instruments, consisting of for example: defibrillator, ventilator, intravenous **system** , chest compressor, scissors, irrigator, stapler, cutter-stapler, grasper, suction device, circular stapler, flexible **endoscope** , injection catheter, **biopsy** catheter, cautery snare catheter, balloon catheter, stent-placement catheter, rotating-blade catheter, drill, routing tool, cutting laser, sealing laser, mechanical sewing tool, bridling tool, probe, camera, needle and tread, scalpel and cannula.

ADVANTAGE - The training evaluation of a team being trained does not require the presence of a live instructor. Each team member does not have to be in the same place as the others.

DESCRIPTION OF DRAWING(S) - The drawing shows the surgery simulation conducted in remote locations via the internet or similar station configuration.

Various remote stations (47,48,49,50)

Connections between remote stations (59,60,61,62)

pp; 19 DwgNo 10/17

Title Terms: FRACTION; **PROCESS** ; SIMULATE; REMOTE; APPARATUS; MULTI; LOCATE; TRAINING; MEDICAL; TEAM; REMOTE; STATION; INTERLINKED; COMMUNICATE; FEEDBACK; INFORMATION
Derwent Class: P85; S05; W02; W04
International Patent Class (Main): G09B-023/28
File Segment: EPI; EngPI

Fractional process **simulator with remote apparatus for multi-location training of medical teams has remote stations interlinked...**

Abstract (Basic):

... Fractional **process** simulator involves the members being located in different places, or stations, as they train together using apparatus in coordinated fashion in relation to numerical data, or **virtual** , non-physical **model** without input from a live instructor.

... use of any of the list of instruments, consisting of for example: defibrillator, ventilator, intravenous **system** , chest compressor, scissors, irrigator, stapler, cutter-stapler, grasper, suction device, circular stapler, flexible **endoscope** , injection catheter, **biopsy** catheter, cautery snare catheter, balloon catheter, stent-placement catheter, rotating-blade catheter, drill, routing tool ...

...Title Terms: **PROCESS** ;

US006074213A

United States Patent [19]

Hon

[11] **Patent Number: 6,074,213**

[45] **Date of Patent: Jun. 13, 2000**

[54] **FRACTIONAL PROCESS SIMULATOR WITH REMOTE APPARATUS FOR MULTI-LOCATIONAL TRAINING OF MEDICAL TEAMS**

[76] Inventor: **David C. Hon**, 1450 NW. Woodbine Way, Seattle, Wash. 98177

[21] Appl. No.: **09/134,945**

[22] Filed: **Aug. 17, 1998**

[51] **Int. Cl.**[7] **G09B 23/28**

[52] **U.S. Cl.** **434/262**; 434/267; 434/272

[58] **Field of Search** 434/262, 267, 434/272

[56] **References Cited**

U.S. PATENT DOCUMENTS

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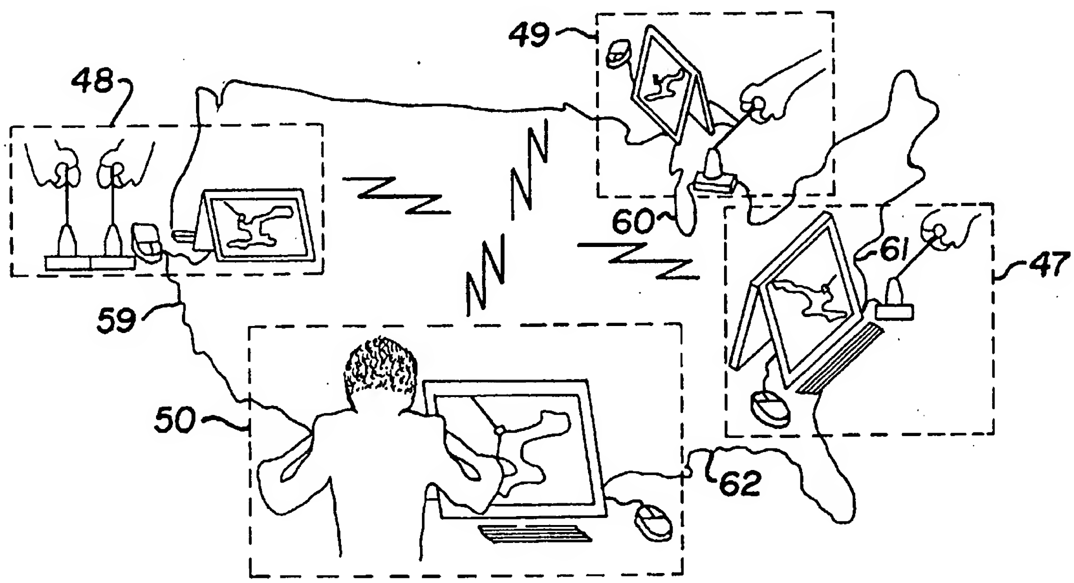
5,909,380	6/1999	Dubois et al.	351/205

Primary Examiner—Valencia Martin-Wallace
Assistant Examiner—Chanda Lynette Harris
Attorney, Agent, or Firm—Crutsinger & Booth; James O. Dixon

[57] **ABSTRACT**

This invention relates to a simulator for training medical teams, the members of which are located in different places, or stations, as they train together using apparatus in coordinated fashion in relation to a numerical data, or virtual, non-physical model without input from a live instructor, wherein each remote station provides a differentiated input with a plurality of differentiated devices, and receives differentiated feedback from the model to each individual station in representations which are visual, tactile, aural, and/or olfactory in their display, depending on the feedback required by each individual station.

20 Claims, 10 Drawing Sheets



32/5,K/10 (Item 10 from file: 350)
DIALOG(R)File 350:Derwent WPIX

013465503 **Image available**
WPI Acc No: 2000-637446/ **200061**
Related WPI Acc No: 1998-437112
XRPX Acc No: N00-472738

Robotics heuristic system **for tissue identification in neuroendoscopy, has CPU which acquires and** processes **data for neural network module and robotic instrument including multimodality probe and cannula**

Patent Assignee: NASA US NAT AERO & SPACE ADMIN (USAS)
Inventor: ANDREWS R J; MAH R W
Number of Countries: 001 Number of Patents: 001
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
US 6109270	A	20000829	US 97795272	A	19970204	200061	B
			US 9817519	A	19980202		

Priority Applications (No Type Date): US 9817519 A 19980202; US 97795272 A 19970204
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
US 6109270	A		16	A61B-010/00	CIP of application US 97795272

Abstract (Basic): US 6109270 A

NOVELTY - The **system** (10) has a robotic instrument (16) having multimodality probe (24) and a cannula (22), and computer **system** (20). The computer **system** has controller to generate **instructions** to control the instrument, a neural network module to adaptively learn information derived by instrument and to provide real time modeling, and a CPU to acquire data from instrument and module and to **process** signals to them.

DETAILED DESCRIPTION - The sensors and tools which are housed within probe, are selected from the group of strain gauge, wick in needle pressure sensor, laser Doppler blood flow sensor, ultrasound probe, **endoscope** , partial pressure of oxygen sensor, optical sensor, temperature sensor, ion specific sensor, microelectrode, tissue ablation laser and an effector.

USE - For tissue identification in neuroendoscopy, **tumor** ablation in neurosurgery, general exploratory surgery, prostate cancer surgery, breast cancer surgery, spinal surgery automated tissue identification for general surgery use, automated stereotactic **biopsy** for neurosurgery, continuous monitoring for patients at risk for cerebral ischemia and/or increased intracranial pressure and for other non-medical applications especially in space machines, long term space exploration travels, hospitals without neurosurgeon.

ADVANTAGE - Improves the diagnostic accuracy and precision of general surgery with near term emphasis on stereotactic brain **biopsy** . Automates tissue identification with emphasis on stereotactic brain **biopsy** to permit remote control of the **procedure** , and reduces morbidity of stereotactic brain **biopsy** . The instrument can be used in conjunction with various surgical tools to increase safety, accuracy and efficiency of surgical **procedures** . Enables to perform surgical **procedures** in automated/robotic fashion for minimizing trauma to the patient because of decreased exposure time in comparison with **procedures** performed manually and/or more invasively.

DESCRIPTION OF DRAWING(S) - The figure shows perspective schematic view of robotic **system** .

Robotics heuristic **system** (10)
Robotic instrument (16)

Computer **system** (20)
Cannula (22)
Probe (24)
pp; 16 DwgNo 1/6

Title Terms: ROBOT; HEURISTIC; **SYSTEM** ; TISSUE; IDENTIFY; CPU; ACQUIRE; **PROCESS** ; DATA; NEURAL; NETWORK; MODULE; ROBOT; INSTRUMENT; PROBE; CANNULA

Derwent Class: P31; S05; T01

International Patent Class (Main): **A61B-010/00**

File Segment: EPI; EngPI

Robotics heuristic system **for tissue identification in neuroendoscopy, has CPU which acquires and** processes **data for neural network module and robotic instrument including multimodality probe and cannula**

Abstract (Basic):

... The **system** (10) has a robotic instrument (16) having multimodality probe (24) and a cannula (22), and computer **system** (20). The computer **system** has controller to generate **instructions** to control the instrument, a neural network module to adaptively learn information derived by instrument...

...real time modeling, and a CPU to acquire data from instrument and module and to **process** signals to them.

... of strain gauge, wick in needle pressure sensor, laser Doppler blood flow sensor, ultrasound probe, **endoscope** , partial pressure of oxygen sensor, optical sensor, temperature sensor, ion specific sensor, microelectrode, tissue ablation...

...For tissue identification in neuroendoscopy, **tumor** ablation in neurosurgery, general exploratory surgery, prostate cancer surgery, breast cancer surgery, spinal surgery automated tissue identification for general surgery use, automated stereotactic **biopsy** for neurosurgery, continuous monitoring for patients at risk for cerebral ischemia and/or increased intracranial...

...the diagnostic accuracy and precision of general surgery with near term emphasis on stereotactic brain **biopsy** . Automates tissue identification with emphasis on stereotactic brain **biopsy** to permit remote control of the **procedure** , and reduces morbidity of stereotactic brain **biopsy** . The instrument can be used in conjunction with various surgical tools to increase safety, accuracy and efficiency of surgical **procedures** . Enables to perform surgical **procedures** in automated/robotic fashion for minimizing trauma to the patient because of decreased exposure time in comparison with **procedures** performed manually and/or more invasively...

...The figure shows perspective schematic view of robotic **system** .
...

...Robotics heuristic **system** (10...

...Computer **system** (20
...Title Terms: **SYSTEM** ;
International Patent Class (Main): **A61B-010/00**

US006109270A

United States Patent [19]

Mah et al.

[11] **Patent Number: 6,109,270**

[45] **Date of Patent: Aug. 29, 2000**

[54] **MULTIMODALITY INSTRUMENT FOR TISSUE CHARACTERIZATION**

[75] Inventors: **Robert W. Mah**, Cupertino, Calif.; **Russell J. Andrews**, Manilus, N.Y.

[73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration**, Washington, D.C.

[21] Appl. No.: **09/017,519**

[22] Filed: **Feb. 2, 1998**

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/795,272, Feb. 4, 1997.

[51] **Int. Cl.**[7] **A61B 10/00**

[52] **U.S. Cl.** **128/920**; 128/924; 606/130; 600/562

[58] **Field of Search** 600/562, 564, 600/566, 567, 568; 606/1, 130; 128/920, 923, 924, 925

[56] **References Cited**

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(List continued on next page.)

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PCT/EP89/01362	5/1990	WIPO .
PCT/ S96/19257	6/1997	WIPO .

OTHER PUBLICATIONS

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Viewgraphs and a set of pictures used in two presentations by Dr. Russell Andrews: (1) at the 1st Asian Congress of Sterotactic, Functional & Computer-Assisted Neurosurgery, in Singapore, on Dec. 11, 1994; and (2) at the International Symposium On Prospective Neurosurgery in the 21st Century, in Japan, on Sep. 22, 1995.

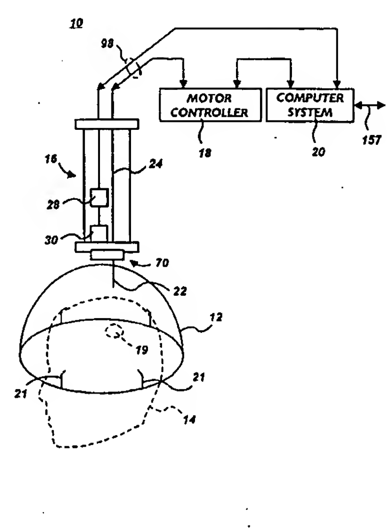
(List continued on next page.)

Primary Examiner—Michael Peffley
Assistant Examiner—R Kearney
Attorney, Agent, or Firm—Robertt M. Padilla; Gary G. Borda; John G. Mannix

[57] **ABSTRACT**

A system with multimodality instrument for tissue identification includes a computer-controlled motor driven heuristic probe with a multisensory tip. For neurosurgical applications, the instrument is mounted on a stereotactic frame for the probe to penetrate the brain in a precisely controlled fashion. The resistance of the brain tissue being penetrated is continually monitored by a miniaturized strain gauge attached to the probe tip. Other modality sensors may be mounted near the probe tip to provide real-time tissue characterizations and the ability to detect the proximity of blood vessels, thus eliminating errors normally associated with registration of pre-operative scans, tissue swelling, elastic tissue deformation, human judgement, etc., and rendering surgical procedures safer, more accurate, and efficient. A neural network program adaptively learns the information on resistance and other characteristic features of normal brain tissue during the surgery and provides near real-time modeling. A fuzzy logic interface to the neural network program incorporates expert medical knowledge in the learning process. Identification of abnormal brain tissue is determined by the detection of change and comparison with previously learned models of abnormal brain tissues. The operation of the instrument is controlled through a user friendly graphical interface. Patient data is presented in a 3D stereographics display. Acoustic feedback of selected information may optionally be provided. Upon detection of the close proximity to blood vessels or abnormal brain tissue, the computer-controlled motor immediately stops probe penetration.

21 Claims, 7 Drawing Sheets



32/5,K/12 (Item 12 from file: 350)
DIALOG(R)File 350:Derwent WPIX

013221892 **Image available**
WPI Acc No: 2000-393766/ **200034**
XRPX Acc No: N00-295660

Endoscope **guiding** method **for radiation** tomography **apparatus, involves obtaining** virtual **visual** image **of bronchus, in alignment with path to a target point, and displaying it as guide image for** endoscope

Patent Assignee: YOKOGAWA MEDICAL SYSTEMS LTD (YOKM)
Number of Countries: 001 Number of Patents: 001
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
JP 2000135215	A	20000516	JP 98310760	A	19981030	200034	B

Priority Applications (No Type Date): JP 98310760 A 19981030
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
JP 2000135215	A		8	A61B-006/03	

Abstract (Basic): JP 2000135215 A

NOVELTY - A 3D image of bronchus is produced from image data of 3D area of an examined object. The path to a target point along the bronchus is obtained from the **image** . A **virtual** visual **image** of the bronchus is obtained in alignment with the path, and is displayed as a guide image (922) for the **endoscope** .

DETAILED DESCRIPTION - An INDEPENDENT CLAIM is also included for **endoscope** guiding apparatus.

USE - For guiding **endoscope** into bronchus, for use in radiation tomography apparatus such as X-ray computed tomography apparatus used during **biopsy** operation.

ADVANTAGE - Enables to reach the **endoscope** to the target point, simply.

DESCRIPTION OF DRAWING(S) - The figure shows model diagram showing guide and live images, displayed during **biopsy** .

Guide image (922)

pp; 8 DwgNo 8/8

Title Terms: **ENDOSCOPE** ; GUIDE; **METHOD** ; RADIATE; TOMOGRAPHY; APPARATUS; OBTAIN; VIRTUAL; VISUAL; IMAGE; BRONCHUS; ALIGN; PATH; TARGET; POINT; DISPLAY; GUIDE; IMAGE; **ENDOSCOPE**
Derwent Class: P31; S03; S05
International Patent Class (Main): A61B-006/03
International Patent Class (Additional): A61B-001/00
File Segment: EPI; EngPI

Endoscope **guiding** method **for radiation** tomography **apparatus, involves obtaining** virtual **visual** image **of bronchus, in alignment with path to a target point, and displaying it as guide image for** endoscope

Abstract (Basic):

... examined object. The path to a target point along the bronchus is obtained from the **image** . A **virtual** visual **image** of the bronchus is obtained in alignment with the path, and is displayed as a guide image (922) for the **endoscope** .

... An INDEPENDENT CLAIM is also included for **endoscope** guiding apparatus...

...For guiding **endoscope** into bronchus, for use in radiation tomography

apparatus such as X-ray computed tomography apparatus used during **biopsy** operation...

...Enables to reach the **endoscope** to the target point, simply...

...The figure shows model diagram showing guide and live images, displayed during **biopsy** .

Title Terms: **ENDOSCOPE** ;

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**(A)　(11)特許出願公開番号
特開2000－135215
(P2000－135215A)
(43)公開日　平成12年5月16日(2000.5.16)

(51)Int.Cl.⁷		識別記号	FI			テーマコード(参考)
A61B	6/03	360	A61B	6/03	360G	4C061
	1/00	300		1/00	300A	4C093

審査請求　未請求　請求項の数4　OL　(全8頁)

(21)出願番号　特願平10－310760
(22)出願日　平成10年10月30日(1998.10.30)

(71)出願人　000121936
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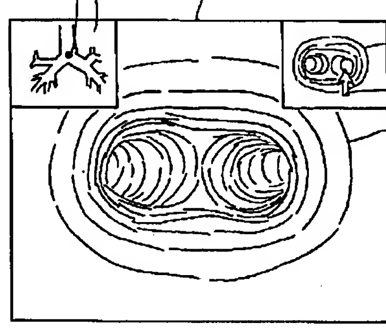
ジーイー横河メディカルシステム株式会社内
(74)代理人　100085187
弁理士　井島　藤治　(外1名)

最終頁に続く

(54)【発明の名称】　管路案内方法および装置並びに放射線断層撮影装置

(57)【要約】
【課題】　内視鏡を目的部位に到達させることを容易にする管路案内方法および装置、並びに、そのような管路案内装置を備えた放射線断層撮影装置を実現する。
【解決手段】　被検体の3次元領域の画像データから体内の管路の3次元像を作成し、3次元像上で管路に沿って目的点までの経路を求め、その経路に沿った管路の仮想的な内視像を3次元画像データから作成し、それを内視鏡挿入の案内画像922として表示する。



32/5,K/15 (Item 15 from file: 350)
DIALOG(R)File 350:Derwent WPIX

013084943 **Image available**
WPI Acc No: 2000-256815/ **200022**
XRAM Acc No: C00-078390
XRPX Acc No: N00-190960

Determination apparatus for location of coils carried on medical or surgical instrument within patient has processor **receiving data from magnetic field gradient and electric potential induced in coils by field**

Patent Assignee: ROBIN MEDICAL INC (ROBI-N)
Inventor: NEVO E
Number of Countries: 085 Number of Patents: 005
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
WO 200013586	A1	20000316	WO 99US20216	A	19990903	200022	B
AU 9958062	A	20000327	AU 9958062	A	19990903	200032	
EP 1112025	A1	20010704	EP 99945468	A	19990903	200138	
			WO 99US20216	A	19990903		
JP 2002524125	W	20020806	WO 99US20216	A	19990903	200266	
			JP 2000568397	A	19990903		
US 6516213	B1	20030204	WO 99US20216	A	19990903	200313	
			US 2001762953	A	20010215		

Priority Applications (No Type Date): US 99144774 P 19990720; US 9899498 P 19980908; US 98106831 P 19981103; US 2001762953 A 20010215

Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
WO 200013586	A1	E	43	A61B-005/05	

Designated States (National): AL AM AT AU AZ BA BB BG BR BY CA CH CN CU CZ DE DK EE ES FI GB GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT UA UG US UZ VN YU ZA ZW
Designated States (Regional): AT BE CH CY DE DK EA ES FI FR GB GH GM GR IE IT KE LS LU MC MW NL OA PT SD SE SL SZ UG ZW

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
AU 9958062	A			A61B-005/05	Based on patent WO 200013586
EP 1112025	A1	E		A61B-005/05	Based on patent WO 200013586

Designated States (Regional): AL AT BE CH CY DE DK ES FI FR GB GR IE IT LI LT LU LV MC MK NL PT RO SE SI

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
JP 2002524125	W		46	A61B-005/055	Based on patent WO 200013586
US 6516213	B1			A61B-005/05	Based on patent WO 200013586

Abstract (Basic): WO 200013586 A1

NOVELTY - Apparatus has a magnetic generator (43,48) producing a time-variable three dimensional field gradient, a coil assembly (20) carried by an object moving through the field, a device measuring instantaneous induced electric potentials in the coils and a **processor** (10,44).

DETAILED DESCRIPTION - The field is generated by a magnetic resonance imaging (MRI) scanner. The assembly has three pairs of coils, the pairs are orthogonal to each other. The object is a catheter for angioplasty, stent placement, gene therapy, studying cardiac electrophysiology or cardiac revascularisation, a **biopsy** needle or gun, an aspiration needle, **endoscope** , motion sensor, ventriculoscope, colonoscope, duodenoscope, gastroscope, laryngoscope, tracheoscope, **bronchoscope** , hysteroscope, urethroscope, cystoscope, ureteroscope or arthroscope. The **processor** performs an interactive optimization to determine the location. INDEPENDENT CLAIMS are also included for instantaneously determining the position of an object in a magnetic field.

USE - For determining location of medical or surgical instruments during **MRI** scanning of **patient** 's body.

ADVANTAGE - It is particularly useful for minimally invasive surgery of the brain or other organs. The **processor** determines the location of the object from the measured electric potentials and the known instantaneous magnitude and **direction** of the field gradient.

DESCRIPTION OF DRAWING(S) - Figure of a block diagram of the determination apparatus.

Processor (10,44)

Coil assembly (20)

Magnetic generator (43,48)

pp; 43 DwgNo 1a/7

Title Terms: DETERMINE; APPARATUS; LOCATE; COIL; CARRY; MEDICAL; SURGICAL; INSTRUMENT; PATIENT; **PROCESSOR** ; RECEIVE; DATA; MAGNETIC; FIELD; GRADIENT; ELECTRIC; POTENTIAL; INDUCE; COIL; FIELD

Derwent Class: B07; P31

International Patent Class (Main): A61B-005/05; A61B-005/055

International Patent Class (Additional): G01R-033/28

File Segment: CPI; EngPI

Determination apparatus for location of coils carried on medical or **surgical instrument within patient has** processor **receiving data from magnetic field gradient and electric potential induced in coils by field**

Abstract (Basic):

... through the field, a device measuring instantaneous induced electric potentials in the coils and a **processor** (10,44).

... a catheter for angioplasty, stent placement, gene therapy, studying cardiac electrophysiology or cardiac revascularisation, a **biopsy** needle or gun, an aspiration needle, **endoscope** , motion sensor, ventriculoscope, colonoscope, duodenoscope, gastroscope, laryngoscope, tracheoscope, **bronchoscope** , hysteroscope, urethroscope, cystoscope, ureteroscope or arthroscope. The **processor** performs an interactive optimization to determine the location. INDEPENDENT CLAIMS are also included for instantaneously...

...For determining location of medical or surgical instruments during **MRI** scanning of **patient** 's body...

...It is particularly useful for minimally invasive surgery of the brain or other organs. The **processor** determines the location of the object from the measured electric potentials and the known instantaneous magnitude and **direction** of the field gradient...

... **Processor** (10,44

...Title Terms: **PROCESSOR** ;

US006516213B1

(12) **United States Patent**
Nevo

(10) **Patent No.:** **US 6,516,213 B1**
(45) **Date of Patent:** **Feb. 4, 2003**

(54) **METHOD AND APPARATUS TO ESTIMATE LOCATION AND ORIENTATION OF OBJECTS DURING MAGNETIC RESONANCE IMAGING**

(75) Inventor: **Erez Nevo**, Natania (IL)

(73) Assignee: **Robin Medical, Inc.**, Baltimore, MD (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/762,953**

(22) PCT Filed: **Sep. 3, 1999**

(86) PCT No.: **PCT/US99/20216**

§ 371 (c)(1),
(2), (4) Date: **Feb. 15, 2001**

(87) PCT Pub. No.: **WO00/13586**

PCT Pub. Date: **Mar. 16, 2000**

(51) **Int. Cl.**[7] **A61B 5/05**
(52) **U.S. Cl.** **600/424**; 600/410
(58) **Field of Search** 600/424, 410, 600/407, 411; 128/899; 324/207.13, 207.22, 260, 207.17, 326

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,307,808 A * 5/1994 Dumoulin et al. 128/653.2
5,425,367 A * 6/1995 Shapiro et al. 128/653.1
5,558,091 A * 9/1996 Acker et al. 600/424
5,913,820 A * 6/1999 Bladen et al. 600/407
6,016,439 A * 1/2000 Acker 600/411

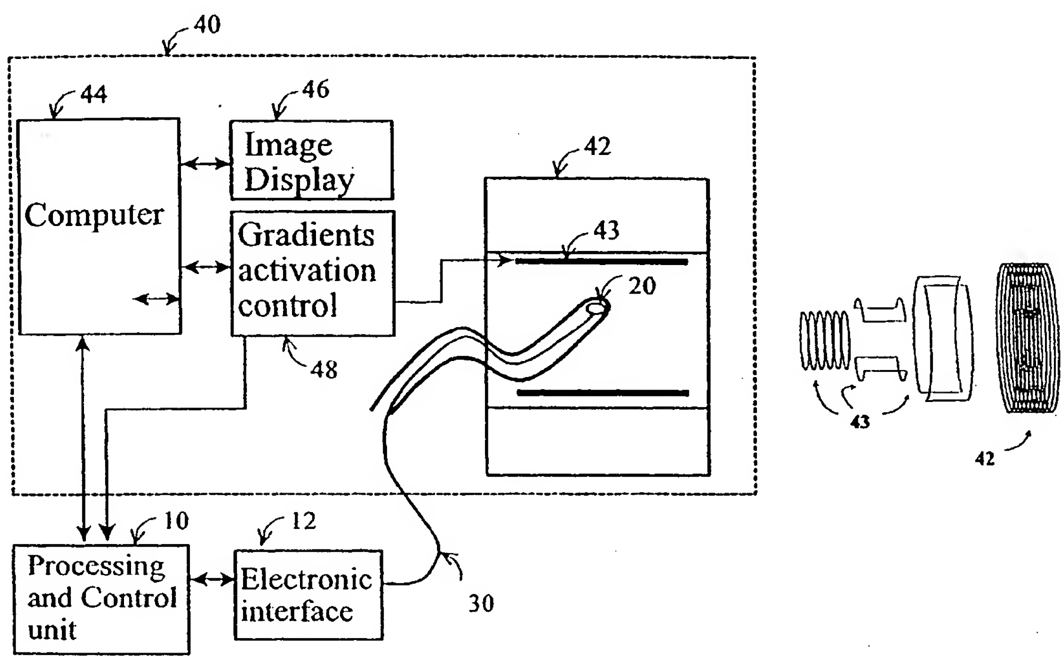
* cited by examiner

Primary Examiner—Teresa Walberg
Assistant Examiner—Quang Van

(57) **ABSTRACT**

Method and apparatus for determining the instantaneous location, the orientation of an object moving through a three-dimensional space by applying to the object a coil assembly including a plurality of sensor coils **(20)** having axes of known orientation with respect to each other including components in the three orthogonal planes; generating a time-varying, three-dimensional magnetic field gradient having known instantaneous values of magnitude and direction; applying the magnetic field gradient to the space, and object moving therethrough to induce electrical potentials in the sensor coils; measuring the instantaneous values of the induced electrical potentials generated in the sensor coils; processing the measured instantaneous values generated in the sensor coils together with the known magnitude, direction of the generated magnetic field gradient, the known relative orientation of the sensor coils in the coil assembly to compute the instantaneous location, orientation of the object within the space.

36 Claims, 7 Drawing Sheets



32/5,K/17 (Item 17 from file: 350)
DIALOG(R)File 350:Derwent WPIX

012867604 **Image available**
WPI Acc No: 2000-039437/ **200003**
XRPX Acc No: N00-029719

Controlled torque generation method **for controlling operation of medical devices, e.g. catheter or** endoscope

Patent Assignee: ROBIN MEDICAL INC (ROBI-N)
Inventor: NEVO E
Number of Countries: 086 Number of Patents: 004
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
WO 9960370	A2	19991125	WO 99IL250	A	19990512	200003	B
AU 9938450	A	19991206	AU 9938450	A	19990512	200019	
EP 1078238	A2	20010228	EP 99921109	A	19990512	200113	
			WO 99IL250	A	19990512		
US 6594517	B1	20030715	US 9885652	P	19980515	200348	
			WO 99IL250	A	19990512		
			US 2000700312	A	20001114		

Priority Applications (No Type Date): US 9885652 P 19980515; US 2000700312 A 20001114
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
WO 9960370	A2	E	26	G01N-000/00	

Designated States (National): AE AL AM AT AU AZ BA BB BG BR BY CA CH CN CU CZ DE DK EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT UA UG US UZ VN YU ZA ZW
Designated States (Regional): AT BE CH CY DE DK EA ES FI FR GB GH GM GR IE IT KE LS LU MC MW NL OA PT SD SE SL SZ UG ZW

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
AU 9938450	A			G01N-000/00	Based on patent WO 9960370
EP 1078238	A2	E		G01N-001/00	Based on patent WO 9960370

Designated States (Regional): DE ES FR GB IT NL

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
US 6594517	B1			A61B-005/055	Provisional application US 9885652; Based on patent WO 9960370

Abstract (Basic): WO 9960370 A2

NOVELTY - An external magnetic field of known magnitude and **direction** is produced within the body. A coil assembly (20) is applied to the device to be controlled. The electric current supplied to the coil assembly is controlled, to generate a resultant magnetic pole that interacts with the external magnetic field to produce a torque of the desired **direction** and magnitude.

DETAILED DESCRIPTION - The coil assembly includes coils which are provided in the three orthogonal planes, so that the coil axes are orthogonal to each other.

An INDEPENDENT CLAIM is also included for a device that implements the **method** .

USE - For regulating operation of medical devices, such as catheter, **endoscopes** , **biopsy** or surgical tool.

ADVANTAGE - Enables real-time MRI with minimum damage to healthy tissues and sensitive organs, thus enabling precise control of position, **direction** and operation of catheter. Replaces complex tension wires to provide smaller catheter.

DESCRIPTION OF DRAWING(S) - The figure shows a catheter being used in an MRI **system** .

Processing and control unit (10)

Electronic interface (12)
Input device (14)
Coil assembly (20)
Device to be controlled, e.g. catheter or **endoscope** (30)
MRI **system** (40)
MRI magnet (42)
Gradient coils (43)
Computer (44)
Image display (46)
Gradient activation control (48)
Location and **direction** module (50)
pp; 26 DwgNo 1/7

Title Terms: CONTROL; TORQUE; GENERATE; **METHOD** ; CONTROL; OPERATE; MEDICAL ; DEVICE; CATHETER; **ENDOSCOPE**
Derwent Class: P31; S01; S03; S05
International Patent Class (Main): A61B-005/055; G01N-000/00; G01N-001/00
International Patent Class (Additional): A61B-001/00
File Segment: EPI; EngPI

Controlled torque generation method **for controlling operation of** **med**ical devices, e.g. catheter or endoscope

Abstract (Basic):

... An external magnetic field of known magnitude and **direction** is produced within the body. A coil assembly (20) is applied to the device to...

...pole that interacts with the external magnetic field to produce a torque of the desired **direction** and magnitude.

... An INDEPENDENT CLAIM is also included for a device that implements the **method** .

...

...For regulating operation of medical devices, such as catheter, **endoscopes** , **biopsy** or surgical tool...

...with minimum damage to healthy tissues and sensitive organs, thus enabling precise control of position, **direction** and operation of catheter. Replaces complex tension wires to provide smaller catheter...

...The figure shows a catheter being used in an MRI **system** .

...

... **Processing** and control unit (10...

...Device to be controlled, e.g. catheter or **endoscope** (30...

...MRI **system** (40...

...Location and **direction** module (50

...Title Terms: **METHOD** ;

US006594517B1

(12) United States Patent
Nevo

(10) Patent No.: US 6,594,517 B1
(45) Date of Patent: Jul. 15, 2003

(54) METHOD AND APPARATUS FOR GENERATING CONTROLLED TORQUES ON OBJECTS PARTICULARLY OBJECTS INSIDE A LIVING BODY

(75) Inventor: Erez Nevo, Natania (IL)

(73) Assignee: Robin Medical, Inc., Baltimore, MD (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 09/700,312

(22) PCT Filed: May 12, 1999

(86) PCT No.: PCT/IL99/00250

§ 371 (c)(1),
(2), (4) Date: Nov. 14, 2000

(87) PCT Pub. No.: WO99/60370

PCT Pub. Date: Nov. 25, 1999

Related U.S. Application Data

(60) Provisional application No. 60/085,652, filed on May 15, 1998.

(51) Int. Cl.^{7} A61B 5/055; A61B 1/00

(52) U.S. Cl. 600/411; 600/117; 600/145; 600/146; 600/424; 128/899

(58) Field of Search 600/411, 424, 600/114, 117, 145, 146; 128/899

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,681,260 A * 10/1997 Ueda et al. 128/899
6,104,944 A * 8/2000 Martinelli 600/424
6,304,769 B1 * 10/2001 Arenson et al. 600/424

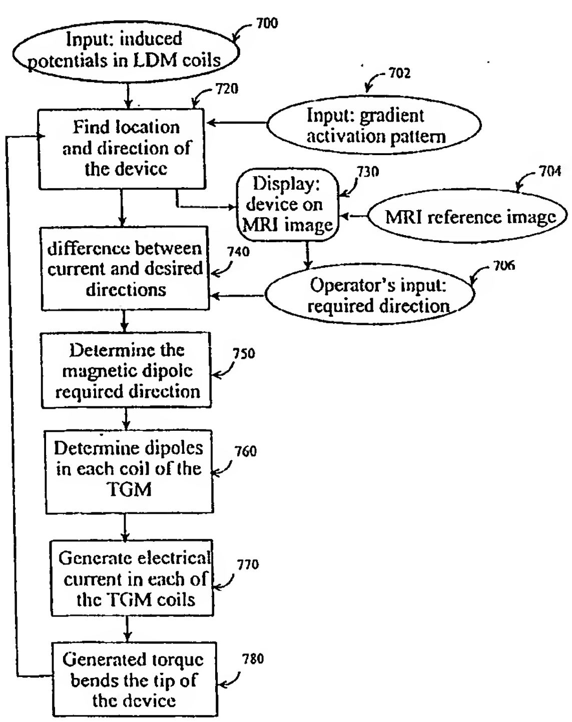
* cited by examiner

Primary Examiner—Ruth S. Smith

(57) **ABSTRACT**

A method and apparatus for generating a controlled torque of a desired direction and magnitude in an object within a body, particularly in order to steer the object through the body, such as a catheter through a blood vessel in a living body, by producing an external magnetic field of known magnitude and direction within the body, applying to the object a coil assembly including preferably three coils of known orientation with respect to each other, preferably orthogonal to each other, and controlling the electrical current through the coils to cause the coil assembly to generate a resultant magnetic dipole interacting with the external magnetic field to produce a torque of the desired direction and magnitude.

18 Claims, 7 Drawing Sheets



32/5,K/23 (Item 23 from file: 350)
DIALOG(R)File 350:Derwent WPIX

010833615 **Image available**
WPI Acc No: 1996-330567/ **199633**
XRPX Acc No: N96-278771
Electronic endoscope **for surgical observation - has cable for image pick-up connected between electrical circuit board and imager through piercing hole**
Patent Assignee: OLYMPUS OPTICAL CO LTD (OLYU)
Number of Countries: 001 Number of Patents: 001
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
JP 8152565	A	19960611	JP 94293276	A	19941128	199633	B

Priority Applications (No Type Date): JP 94293276 A 19941128
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
JP 8152565	A		11	G02B-023/24	

Abstract (Basic): JP 8152565 A
The **endoscope** has an imager (13) arranged in axial **direction** of an insertion. A circuit board (14) mounts an electronic component (15) that are electrically connected in parallel at the back of the imager.
A cable (16) for image pick-up pierced through a hole (43) is connected electrically between the circuit board and the imager.
ADVANTAGE - Works and **processes** observation with high efficiency. Improves **curve** operation of insertion. Facilitates e.g. **biopsy** treatment, observation of intra-corporeal, front view of target part and excision and accurately doing observation treatment.
Dwg.1/11
Title Terms: ELECTRONIC; **ENDOSCOPE** ; SURGICAL; OBSERVE; CABLE; IMAGE; PICK ; UP; CONNECT; ELECTRIC; CIRCUIT; BOARD; IMAGE; THROUGH; PIERCE; HOLE
Derwent Class: P31; P81; S05
International Patent Class (Main): G02B-023/24
International Patent Class (Additional): **A61B-001/04**
File Segment: EPI; EngPI
Electronic endoscope **for surgical observation...**

...Abstract (Basic): The **endoscope** has an imager (13) arranged in axial **direction** of an insertion. A circuit board (14) mounts an electronic component (15) that are electrically...

...ADVANTAGE - Works and **processes** observation with high efficiency. Improves **curve** operation of insertion. Facilitates e.g. **biopsy** treatment, observation of intra-corporeal, front view of target part and excision and accurately doing...
...Title Terms: **ENDOSCOPE** ;
International Patent Class (Additional): **A61B-001/04**

32/5,K/26 (Item 26 from file: 350)
DIALOG(R)File 350:Derwent WPIX

010056434 **Image available**
WPI Acc No: 1994-324145/ **199440**
XRPX Acc No: N94-254558

Magnetic resonance tracking system **for monitoring device e.g. catheter inside patient - has controller activating RF transmitter, MR response detector, computer and magnetic field varying unit, according to zero reference magnitude resonance tracking sequence**

Patent Assignee: GENERAL ELECTRIC CO (GENE)
Inventor: DARROW R D; DUMOULIN C L; SOUZA S P
Number of Countries: 001 Number of Patents: 001
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Week	
US 5353795	A	19941011	US 92989283	A	19921210	199440	B

Priority Applications (No Type Date): US 92989283 A 19921210
Patent Details:

Patent No	Kind	Lan	Pg	Main IPC	Filing Notes
US 5353795	A		15	A61B-005/055	

Abstract (Basic): US 5353795 A

The device has a receiver coil which is sensitive to magnetic resonance signals generated in the subject. These signals are detected in the presence of magnetic field gradients and thus have frequencies which are proportional to the location of the coil along the **direction** of the applied gradient. Signals are detected responsive to applied magnetic gradients to determine the position of the device in several dimensions.

The **process** is repeated a number of times with selected amplitudes and polarities for the applied magnetic field gradient. Linear combinations of the data acquired responsive to the different applied magnetic field gradients are computed to determine the position of the device in three orthogonal dimensions. The position of the device as determined by the tracking **system** is superimposed upon independently acquired medical diagnostic images.

USE/ADVANTAGE - Device may be guide wire, **endoscope** , laparoscope or **biopsy** needle. Tracks device at near real-time rate without requiring substantial additional equipment.

Dwg.3/7

Title Terms: MAGNETIC; RESONANCE; TRACK; **SYSTEM** ; MONITOR; DEVICE; CATHETER; PATIENT; CONTROL; ACTIVATE; RF; TRANSMIT; RESPOND; DETECT; COMPUTER; MAGNETIC; FIELD; VARY; UNIT; ACCORD; ZERO; REFERENCE; MAGNITUDE ; RESONANCE; TRACK; SEQUENCE
Index Terms/Additional Words: MEDICAL; GUIDE; WIRE; ENDOSCOPE; LAPAROSCOPE; BIOPSY; NEEDLE
Derwent Class: P31; S02; S05
International Patent Class (Main): A61B-005/055
File Segment: EPI; EngPI

Magnetic resonance tracking system **for monitoring device e.g. catheter inside patient...**

...Abstract (Basic): and thus have frequencies which are proportional to the location of the coil along the **direction** of the applied gradient. Signals are detected responsive to applied magnetic gradients to determine the...

...The **process** is repeated a number of times with selected amplitudes and

polarities for the applied magnetic...

...device in three orthogonal dimensions. The position of the device as determined by the tracking **system** is superimposed upon independently acquired medical diagnostic images...

...USE/ADVANTAGE - Device may be guide wire, **endoscope** , laparoscope or **biopsy** needle. Tracks device at near real-time rate without requiring substantial additional equipment...

...Title Terms: **SYSTEM** ;

32/5,K/31 **(Item 31 from file: 347)**
DIALOG(R)File 347:JAPIO

06764862 **Image available**
OPERATION IMAGING DISPLAY APPARATUS

PUB. NO.: 2000-350734 [JP 2000350734 A]
PUBLISHED: December 19, 2000 (**20001219)**
INVENTOR(s): SAITO AKITO
SHIBAZAKI TAKAO
KOSAKA AKIO
ASANO TAKEO
MATSUZAKI HIROSHI
FURUHASHI YUKITO
APPLICANT(s): OLYMPUS OPTICAL CO LTD
APPL. NO.: 11-163964 [JP 99163964]
FILED: June 10, 1999 (19990610)
INTL CLASS: **A61B-019/00** ; **A61B-001/04** ; G02F-001/13357

ABSTRACT

PROBLEM TO BE SOLVED: To enable a smooth operation progress without switchover operation of observed **system** by operator when operation is conducted by jointly using operation microscope and plural observation **systems** by providing a directing means for directing what image should be displayed on an image display means adapting to the position and posture of the observed part.

SOLUTION: While an operation image pickup display apparatus is working, a sensor controller 5e makes each infrared LED 5a emit light sequentially, measures the three-dimensional position of each infrared LED 5a from output of a sensor assembly 5d, and calculates the three-dimensional position and posture of sensing plates 5b and 5c using the LED definition data memorized in a sensor controller 5e. An image controlling controller 7 calculates the relative **distance** and **direction** between a patient 6 **operating** part and an **operation** microscope 1 or an **endoscope** 2 by the three-dimensional position and posture information, sends **direction** to a video mixer 3, when the **endoscope** 2 is judged to be near the operating part, to switch over to the **endoscope** observation image, and, when the **endoscope** 2 is judged not to be near the operating part, to the microscope observation image, and displays the observed image on an LC display 4.

...PUBLISHED: **20001219)**
INTL CLASS: **A61B-019/00** ; **A61B-001/04** ; G02F-001/13357
ABSTRACT
PROBLEM TO BE SOLVED: To enable a smooth operation progress without switchover operation of observed **system** by operator when operation is conducted by jointly using operation microscope and plural observation **systems** by providing a directing means for directing what image should be displayed on an image...

... data memorized in a sensor controller 5e. An image controlling controller 7 calculates the relative **distance** and **direction** between a patient 6 **operating** part and an **operation** microscope 1 or an **endoscope** 2 by the three-dimensional position and posture information, sends **direction** to a video mixer 3, when the **endoscope** 2 is judged to be near the operating part, to switch over to the **endoscope** observation image,

and, when the **endoscope** 2 is judged not to be near the operating part, to the microscope observation image...

US006456868B2

(12) **United States Patent**
Saito et al.

(10) **Patent No.: US 6,456,868 B2**
(45) **Date of Patent: Sep. 24, 2002**

(54) **NAVIGATION APPARATUS AND SURGICAL OPERATION IMAGE ACQUISITION/DISPLAY APPARATUS USING THE SAME**

(75) Inventors: **Akito Saito**, Hino; **Takao Shibasaki**, Tokyo; **Takeo Asano**, Kunitachi; **Hiroshi Matsuzaki**, Hachioji; **Yukihito Furuhashi**, Hachioji; **Akio Kosaka**, Hachioji, all of (JP)

(73) Assignee: **Olympus Optical Co., Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/875,628**

(22) Filed: **Jun. 6, 2001**

Related U.S. Application Data

(62) Division of application No. 09/533,651, filed on Mar. 22, 2000.

(30) **Foreign Application Priority Data**

Mar. 30, 1999 (JP) 11-089405
Jun. 10, 1999 (JP) 11-163964

(51) **Int. Cl.**[7] **A61B 5/055**
(52) **U.S. Cl.** **600/429**; 600/407; 600/113; 600/101; 606/130; 348/47; 348/72
(58) **Field of Search** 600/429, 407, 600/416, 417, 109, 117, 113, 160, 473, 476, 101, 110, 111, 118; 606/130; 378/62, 63; 348/45, 47, 72, 65, 79

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,572,999 A	* 11/1996	Funda et al.	
5,638,819 A	* 6/1997	Manwaring et al.	

FOREIGN PATENT DOCUMENTS

JP	5-203881	8/1993
JP	7-261094	10/1995
JP	9-173352	7/1997
JP	10-5245	1/1998

OTHER PUBLICATIONS

Office Action (Final Rejection) dated Feb. 20, 2002 issued in parent application Ser. No. 09/533,651 filed Mar. 22, 2000—Inventors: Akito Saito et al (7 pages).

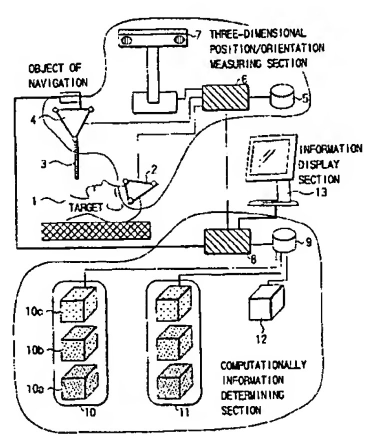
* cited by examiner

Primary Examiner—Marvin M. Lateef
Assistant Examiner—Runa Shah Qaderi
(74) *Attorney, Agent, or Firm*—Frishauf, Holtz, Goodman & Chick, P.C.

(57) **ABSTRACT**

A navigation apparatus comprises a navigation-related information generating section and a display section. The navigation-related information generating section measures the position and orientation of an object and a target in a three-dimensional space and generate navigation-related information to be used for navigating the object toward the target. The display section displays the navigation-related information generated by the navigation-related information generating section in any of different modes depending on the relationship of the position and orientation of the object and that of the target. A surgical operation image acquisition/display apparatus comprises an observation section, an image display section and a specifying section. The observation section includes a plurality of observation sections whose position and orientation is modifiable. The image display section is adapted to alternatively display any of the images obtained by the observation sections or synthetically combine and display the combined images. The specifying section specifies the image to be displayed to the image display section according to the position and orientation of the observation section.

15 Claims, 16 Drawing Sheets



32/5,K/36 (Item 36 from file: 347)
DIALOG(R)File 347:JAPIO

05750367 **Image available**
ENDOSCOPE

PUB. NO.: 10-033467 [JP 10033467 A]
PUBLISHED: February 10, 1998 (**19980210)**
INVENTOR(s): MORI TETSUAKI
APPLICANT(s): OLYMPUS OPTICAL CO LTD [000037] (A Japanese Company or Corporation), JP (Japan)
APPL. NO.: 08-196509 [JP 96196509]
FILED: July 25, 1996 (19960725)
INTL CLASS: [6] **A61B-001/00 ; A61B-001/00**
JAPIO CLASS: 28.2 (SANITATION -- Medical); 29.2 (PRECISION INSTRUMENTS -- Optical Equipment)
JAPIO KEYWORD: R012 (OPTICAL FIBERS); R101 (APPLIED ELECTRONICS -- Video Tape Recorders, VTR); R134 (METALS -- Shape Memory Alloys)

ABSTRACT

PROBLEM TO BE SOLVED: To improve durability of an operation cannel as well as **handling** of the **endoscope** .

SOLUTION: Closer to top end of the **inserter** of the **endoscope** is **processed** a flexible tube 11 capable of **curve** movement to change the **direction** of the **inserter** . Inside the **inserter** are put a signal cable 35 extending from the camera to take photos of subjects, an operation tube 32 for a operation channel 24 as a tube path to put through instruments into the body cavity and/or to suck in body fluids, light guides 25a, 25b to let the light from a light source into top of the inserter and an air/water feed cannel 26 as a tube path to feed the fluids to top of the inserter. The operation channel 24 is put approximately at the center of the flexible tube 11 inside while the air/water feed channel 26 and other components are put in the space between wire guides 30a-30d and the operation tube 32 and a flexible tube 19 around the operation channel 24 as shown on the sketch.

ENDOSCOPE

...PUBLISHED: **19980210)**
INTL CLASS: **A61B-001/00 ; A61B-001/00**

ABSTRACT

PROBLEM TO BE SOLVED: To improve durability of an operation cannel as well as **handling** of the **endoscope** .

...

...SOLUTION: Closer to top end of the **inserter** of the **endoscope** is **processed** a flexible tube 11 capable of **curve** movement to change the **direction** of the **inserter** . Inside the **inserter** are put a signal cable 35 extending from the camera to take photos of subjects

32/5,K/37 **(Item 37 from file: 347)**

04862689 **Image available**
ENDOSCOPE APPARATUS

PUB. NO.: 07-155289 [JP 7155289 A]
PUBLISHED: June 20, 1995 (**19950620)**
INVENTOR(s): UCHIMURA SUMIHIRO
APPLICANT(s): OLYMPUS OPTICAL CO LTD [000037] (A Japanese Company or Corporation), JP (Japan)
APPL. NO.: 05-303046 [JP 93303046]
FILED: December 02, 1993 (19931202)
INTL CLASS: [6] **A61B-001/04** ; **A61B-001/00** ; **A61B-001/00** ; G02B-023/24; G02B-023/26
JAPIO CLASS: 28.2 (SANITATION -- Medical); 29.2 (PRECISION INSTRUMENTS -- Optical Equipment)
JAPIO KEYWORD:R002 (LASERS); R005 (PIEZOELECTRIC FERROELECTRIC SUBSTANCES); R098 (ELECTRONIC MATERIALS -- Charge Transfer Elements, CCD & BBD)

ABSTRACT
PURPOSE: To **insert** automatically an **endoscope** **inserting** part into a ductal cavity by a simple constitution.

CONSTITUTION: An image-picked-up signal of the large intestine 11 picked up by means of a scope 1 is transmitted to a video **processor** 14 through a light guide connector 13 and an observational image is formed from the image-picked- up signal by means of this video **processor** 14. The formed observational image is transmitted to an image **processor** 15 and after the observational image is made into binary values based on a specified brightness as a standard in the image **processor** 15, a dark region is extracted from the observational image and it is transmitted to an MPU 16 as dark region data. In the MPU 16, the center of the dark region is calculated from the dark region data and the advancing **direction** and **distance** of **insertion** of the scope 1 are determined and the determined advancing **direction** and **distance** are output into a scope controller 17 and the inserting part 1a of the scope 1 is **inserte**d based on the advancing **direction** and **distance** of the **insertion** by the scope controller 17.

ENDOSCOPE APPARATUS

...PUBLISHED: **19950620)**
INTL CLASS: **A61B-001/04** ; **A61B-001/00** ; **A61B-001/00** ; G02B-023/24; G02B-023/26
ABSTRACT
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32/5,K/40 **(Item 40 from file: 347)**
DIALOG(R)File 347:JAPIO

01912418 **Image available**
ENDOSCOPE DEVICE

PUB. NO.: 61-126518 [JP 61126518 A]
PUBLISHED: June 14, 1986 (**19860614)**
INVENTOR(s): AMANO ATSUSHI
TANIGAWA KOJI
ONO KUNIO
KAIYA HARUHIKO
OGAWA MOTOTSUGU
APPLICANT(s): OLYMPUS OPTICAL CO LTD [000037] (A Japanese Company or Corporation), JP (Japan)
APPL. NO.: 59-249152 [JP 84249152]
FILED: November 26, 1984 (19841126)
INTL CLASS: [4] G02B-023/26; **A61B-001/04** ; H04N-005/335; H04N-007/18
JAPIO CLASS: 29.2 (PRECISION INSTRUMENTS -- Optical Equipment); 28.2 (SANITATION -- Medical); 44.6 (COMMUNICATION -- Television)
JAPIO KEYWORD:R012 (OPTICAL FIBERS)
JOURNAL: Section: P, Section No. 510, Vol. 10, No. 316, Pg. 91, October 28, 1986 (19861028)

ABSTRACT

PURPOSE: To reduce the **diameter** of the tip of the **insertion** part of an **endoscope** device by providing a scanning optical **system** which projects thin and long illumination light in the **lengthwise direction** of the **insertion** part and moves the illumination light in a crossing **direction** , and providing a line sensor along the **lengthwise direction** of the **insertion** part.

CONSTITUTION: Linear illumination light projected from the projection end surface 15 of a light guide 14 is reflected by a reflecting surface 8 of the rotating tetrahedral body 6 of the scanning optical **system** 4 which faces a lighting window 2 to rotate in a peripheral **direction** of the **insertion** part 1. The illumination range at this time is parallel to the **lengthwise direction** of the **insertion** part 1 and the beltlike illumination light scans an observed part by its rotation with time. Then, the beltlike lighted range to be observed is made incident on respective picture elements of the line sensor 5 through the cylindrical lens 16 in the observation window 3, so that the image is projected on a monitor 21 through an amplifier 18, a sample holding circuit 19, and a video **process** circuit 20.

ENDOSCOPE DEVICE
...PUBLISHED: **19860614)**
INTL CLASS: G02B-023/26; **A61B-001/04** ; H04N-005/335; H04N-007/18

ABSTRACT

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Artificial Intelligence
Volume 88, Issues 1-2, December 1996, Pages 1-38

doi:10.1016/0004-3702(95)00119-0 Cite or link using doi

Using hidden nodes in Bayesian networks

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Available online 16 February 1999.

Abstract

In the construction of a Bayesian network, it is always assumed that the variables starting from the same parent are conditionally independent. In practice, this assumption may not hold, and will give rise to incorrect inferences. In cases where some dependency is found between variables, we propose that the creation of a hidden node, which in effect models the dependency, can solve the problem. In order to determine the conditional probability matrices for the hidden node, we use a gradient descent method. The objective function to be minimised is the squared-error between the measured and computed values of the instantiated nodes. Both forward and backward propagation are used to compute the node probabilities. The error gradients can be treated as updating messages and can be propagated in any direction throughout any singly connected network. We used the simplest node-by-node

creation approach for parents with more than two children. We tested our approach on two different networks in an endoscope guidance system and, in both cases, demonstrated improved results.

Corresponding author.

Artificial Intelligence
Volume 88, Issues 1-2 , December 1996, Pages 1-38

Applied Virtual Reality for Simulation of Endoscopic Retrograde
W. David / Curtis, MD, Aug 1998
...aid in the **process** of digestion. After the **endoscope** is positioned...desired ductal **system** (biliary...papilla. To **guide** the catheter...obstructed biliary **system** and cannot...drainage **procedures**, and (c...which an **endoscope** is inserted...simulation **parameters**, and a video...tracking **systems**, the three-dimensional...orientation of the **endoscope** and the catheter...actual ERCP **procedure**, the physician...decision making **process**. The GIT...

[http://www.bitc.gatech.edu/bitcprojects/ercp/paper46.h...]

Applied Virtual Reality for Simulation of Endoscopic Retrograde Cholangio-Pancreatography (ERCP)

by

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ABSTRACT

Researchers from the Georgia Institute of Technology and the Medical College of Georgia (GIT/MCG) have developed an interactive computer simulation of Endoscopic Retrograde Cholangio-Pancreatography (ERCP). ERCP is a minimally invasive technique for evaluating and treating pathologic conditions of the biliary and pancreatic ducts. While ERCP provides the patient with substantial advantages over traditional methods, ERCP requires advanced skills and extensive experience to minimize the risk of complications. Computer simulation offers many advantages for efficiently and safely training physicians in ERCP. The GIT/MCG proof of concept simulation provides realistic training with both visual and force feedback while an endoscopist practices the ERCP procedure.

INTRODUCTION

ERCP involves passing an endoscope with a flexible tip through the oral cavity, the esophagus, the stomach and into the first portion of the small intestine, the duodenum. The endoscope is maneuvered in the duodenum until the major duodenal papilla is identified. The papilla is a nodular protuberance on the medial wall of the duodenum through which the bile duct and pancreatic duct expel bile and pancreatic juice respectively into the duodenum to aid in the process of digestion. After the endoscope is positioned near the major duodenal papilla, a catheter is inserted through a channel of the endoscope and directed into the desired ductal system (biliary or pancreatic) by changing the position of the flexible endoscope tip in relation to the papilla. An "elevator" apparatus at the tip of the endoscope can also be utilized to adjust the angle at which the catheter enters the papilla. To guide the catheter into the papilla, the physician relies on visual feedback from the endoscopic video display and tactile resistance encountered when advancing the catheter. In diagnostic ERCP, contrast dye is injected through the catheter while fluoroscopic images are observed and roentgenograms are obtained. On the fluoroscopic display, the catheter tip can be

located, but, unless contrast is injected, the anatomical structures are essentially invisible. In therapeutic ERCP, instruments are used that can enlarge the opening of the ducts (sphincterotomy), collect biopsy samples, remove stones, and place stents.

The major benefit of ERCP is that it allows patients to avoid more invasive surgical or radiological procedures. The therapeutic applications of ERCP (removal of bile duct stones, repair of bile duct injuries, stenting of obstructed bile ducts, etc.) significantly lower the risk of infection, speed recovery time, and reduce the cost of delivering care. Therapeutic ERCP continues to be among the most rapidly evolving disciplines in gastrointestinal endoscopy. New applications are being aggressively developed to further lower patient risk and the cost of care. The major risks associated with ERCP include (a) pancreatitis (inflammation of the pancreas gland), usually resulting from repeated injections of the pancreatic duct or improperly performed therapeutic techniques (b) cholangitis (infection in the bile ducts) which can result when contrast material is injected into an obstructed biliary system and cannot be removed by appropriate drainage procedures, and (c) perforation of the duodenum, which can occur during more advanced therapeutic biliary procedures. As trainees become more adept at performing ERCP, the risk of these complications is greatly reduced. Thus, safe repetitive practice on a computer simulator is highly advantageous.

The GIT/MCG ERCP simulator consists of a simulation interface into which an endoscope is inserted, a computer which controls and updates the virtual environment, a dial and button box for selecting simulation parameters, and a video monitor to display computer generated imagery. A simulation session begins as a real endoscope is inserted through the "mouth" of the simulated patient. The endoscope is guided into position using standard endoscopic techniques. A position tracking system reports the endoscope movements to a high performance Silicon Graphics computer which controls the interactions and updates the computer generated imagery on the monitor. In addition to the visual feedback displayed on the monitor, a computer controlled arrangement of servo motors provides force feedback to the endoscope and catheter held by the trainee.

PHYSICAL SIMULATION INTERFACE

The simulation interface for the ERCP simulator, shown in Figure 1, includes the physical components that the trainee sees and controls. These components approximate the physical environment for clinical endoscopy. During ERCP, the patient lies on his side on an examination table. After sedating the patient, the physician guides the endoscope through the patient's mouth and then navigates through endoscopic manipulation into position while observing the internal endoscopic view on a video monitor beside the exam table.

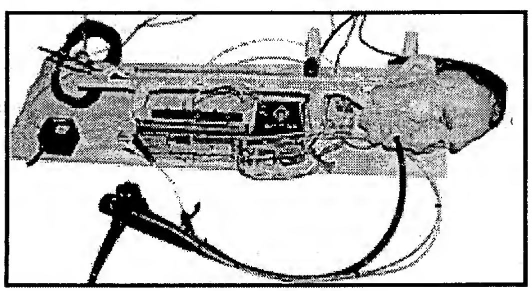

Figure 1. GIT/MCG Endoscopic Simulation Interface

In the GIT/MCG simulator, the trainee holds a real endoscope (donated by Olympus) that has already been passed through the mouth in a mannequin head. Generally hidden from view by a hospital gown or sheet, the end of the endoscope is attached to a movable track inside the simulated patient. As the scope is advanced by the trainee, the scope slides smoothly along this moving track. At the locations where the scope is attached to the moving track, it is supported by circular rings with bearings that allow the scope to freely rotate when the trainee applies torque. The end of the endoscope extends several inches beyond the final circular attachment, and it can move freely in space in response to the up/down and left/right controls on the endoscope. The final steps in ERCP are performed by advancing a catheter through the instrument channel in the endoscope, and positioning the catheter by adjusting an "elevator" control on the scope's handle. Small modifications were made to the Olympus scope to support the catheter movements and the control of the elevator. Instead of passing through the central instrument channel, the catheter is rerouted through a tube to a linear transducer that tracks how far the catheter has been advanced. Similar tubing connects a guide wire attached to the elevator control with a linear transducer measuring the elevator control position. These small modifications to the Olympus scope do not noticeably alter the weight or feel of the endoscope controls.

The ERCP simulation interface also includes a programmable dial and button box that allows the user to select from a set of display and training options. Training sessions can be recorded and then played back from a different perspective. Buttons can also select from a variety of anatomical models. In the future, this box will be programmed to present catastrophic, unusual, or classic cases that every student would be exposed to. Training sessions could also incorporate credentialing criteria that would measure performance and skill level.

POSITION TRACKING

The movable track supporting the simulator's endoscope follows a straight path, but the endoscope's movements are directly related to an anatomically correct, three-dimensional (3D) path through the virtual anatomy. The position and orientation of the scope in the virtual anatomy is determine by how far the endoscope has been advanced and rotated in the simulator interface. These motions are tracked by a Polhemus FastTrack system that is attached to the end of the endoscope (Figure 2) and transferred to the simulation computer which updates the display appropriately.

Figure 2. Simulation interface with position tracking on the end of the endoscope.

If the endoscope is advanced five centimeters into the mouth of the simulator, the virtual endoscope on the display advances five centimeters along the 3D gastrointestinal path in the virtual anatomy. The Polhemus is an off-the-shelf product that tracks and reports the position and orientation of a small sensor as it moves through a calibrated magnetic field. In the ERCP simulator, the Polhemus sensor is attached to the end of the endoscope and the magnetic field source is fixed near the moving track. Because metallic components can interfere with the magnetic tracking system, the ERCP simulation interface is primarily constructed from non-metallic components that will not distort the magnetic field. The Polhemus sensor on the endoscope tracks the movement of the endoscope through the virtual anatomy, but the catheter motions relative to the endoscope position are tracked separately by the linear transducers mentioned earlier. Through these tracking systems, the three-dimensional position and orientation of the endoscope and the catheter relative to the virtual anatomy are accurately represented in the simulation.

FORCE FEEDBACK

As the endoscope is maneuvered into position and the catheter is advanced during an actual ERCP procedure, the physician experiences a variety of force feedback information that contributes to his decision making process. The GIT/MCG simulation approximates force feedback in several ways. First, as the endoscope advances through the virtual anatomy, the up/down and left/right movements are constrained by the diameter of the current passage way. For example, through the esophagus, the endoscope can not be easily turned up/down or left/right because the endoscope is squeezing through this relatively narrow passageway. However, in the stomach, there is little or no resistance to the up/down and left/right controls as the endoscope moves freely in the cavity of the stomach. In the simulator, the force feedback associated with this restricted movement is approximated by reducing the range of up/down and left/right motion. Specifically, a flexible line connected to the end of the endoscope is pulled tight by a servo motor when the endoscope is moving through a tight passageway in the virtual anatomy, thus restricting its instantaneous radius of movement. The servo motor allows more slack in the line as the endoscope moves through less narrow passageways in the anatomy, and the line does not restrict the up/down and left/right movements at all as the endoscope passes through the stomach.

Force feedback is also produced as the catheter is advanced toward the major papilla. During ERCP, the catheter can be guided into the bile or pancreatic ducts if the catheter is positioned correctly before advancing toward the papilla. However, if the catheter misses the mark, it will distort the papilla and push back against the endoscope. The GIT/MCG simulator tracks the position of the catheter in relation to the surrounding anatomy, and if the catheter is positioned correctly, it will advance through the papilla into one of the ducts. If the catheter is advanced and it misses the papilla, the simulator produces surface deformation in the neighborhood of the papilla, and a compliant force feedback is applied to the end of the catheter by a servo motor in the simulation interface.

VISUAL SIMULATION

While force feedback is present and helpful, the physician relies primarily on visual feedback while navigating through the ERCP procedure. The GIT/MCG simulation provides computer generated visual feedback from the endoscope using texture mapped three-dimensional computer models that can be displayed and manipulated in real time. The visual simulation presents the correct endoscopic perspective and field of view. The simulated view of the three-dimensional anatomy transitions naturally in real time as the endoscope is guided into position,

and the catheter is directed toward the papilla. The visual simulation is accomplished by moving a three-dimensional viewing window through the virtual anatomy in response to the instrument tracking information reported to the simulation computer. It is a real-time, interactive simulation that relies on rapid updates from the instrument tracking system and corresponding responses in the graphics display. The correct three-dimensional viewing window (defined by the endoscope's optical parameters) and rapid display updates are achieved through GL subroutine calls to the graphics subsystem on a high performance Silicon Graphics Onyx computer.

The virtual components of the visual simulation include three-dimensional computer models of the endoscope, the cannula, the endoscopic light (viewing frustum), and anatomical models of the gastrointestinal tract, gall bladder, pancreas, and the associated ducts merging into the major papilla. The standard display mode presents the endoscopic view, but a second viewing option presents an external view of the endoscope in relation to the surrounding anatomy. The second view, not available in real life, is presented to help training physicians to better understand the 3D geometry and positioning maneuvers. In the standard display mode, the only portions of the anatomy that are seen are the interior gastrointestinal tract, and the only instruments that are displayed are those that are advanced through the operating channel (such as the catheter). In the second, external view, the endoscope is displayed and the trainee can selectively display the surrounding anatomy with opaque or semitransparent properties. Another option in the external view is to display a light cone representing the current viewing direction. Both views as illustrated in Figure 3 can be displayed simultaneously on the computer console, and a button on the

Figure 3. Internal and external view from GIT/MCG endoscopic simulation.

simulation interface provides a toggle to switch between these views on the video monitor beside the patient interface.

A final step in ERCP is selective cannulation of the bile and pancreatic ducts. Just as in practice, this is controlled in the simulation by advancing a catheter into the endoscope and adjusting the elevator. Movements of the catheter and the elevator are measured by tracking components in the simulation interface and passed on to the simulation computer which continuously updates the display of the virtual catheter interacting with the virtual anatomy. The stomach, duodenum, and papilla are represented by three-dimensional computer models that are texture mapped with photographic images of the anatomy acquired during endoscopic examinations. The major duodenal papilla is represented by a compliant deformable polygonal surface that deforms as the catheter probes the anatomy in the vicinity of the papilla. Upon successful cannulation, the simulator changes the color of the virtual catheter to represent which duct has been entered; green for the bile duct and blue for the pancreatic duct.

DISCUSSION

It is the interactive three-dimensional aspect that best differentiates the GIT/MCG medical simulation approach from other endoscopic simulation efforts. Interactive simulation allows the user to manipulate three-dimensional computer models and see the response in real-time. Pushing or pulling the models produces immediate and appropriate model deformation. Furthermore, the GIT/MCG prototype includes force feedback that is important to provide realistic skills training. Other groups have produced endoscopic simulations based upon much less expensive but also less powerful computer platforms. The computer limitations have forced these other groups to rely on simplified graphics and a video-disk with two-dimensional graphic overlays to simulate endoscopic manipulation. These approaches provide useful examples of procedural steps, but they do not simulate the full three-dimensional aspect of the procedure. Computer cost and performance trends continue to move in the right direction for supporting increasingly affordable and realistic medical simulation. At the same time there is growing acceptance within the medical community for computer assisted training. The next important step in medical simulation is to convincingly demonstrate that this technology can reduce the learning curve in a clinical training program.

ACKNOWLEDGMENT

This research has been funded by a grant from the Georgia Tech / Medical College of Georgia Biomedical Research and Education Program.

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Top of Page

DESIGNING FOR SPATIAL ORIENTATION IN ENDOSCOPIC ENVIRONMENTS

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Disorientation or "getting lost" in colonoscopy is common experience even for expert endoscopists. This paper describes a new navigational aid display concept for colonoscopy and presents results of an experiment conducted to evaluate the usefulness of various types of spatial information for supporting navigation and spatial orientation in colonoscopy. Six combinations of 1) direction, 2) location, and 3) shape information were tested. Results show that even though the new navigational aid display concept did not improve navigation performance, spatial orientation error and workload were reduced significantly. This new navigational aid display which provides shape combined with location and direction information in a perspective view and in real time is a useful tool for colonoscopy.

INTRODUCTION

Colorectal cancer is the second leading cause of cancer death in Canada (National Cancer Institute of Canada, 2001). Colonoscopy is now widely used in the investigation of suspected colorectal disease, and as a screening procedure for high-risk individuals (Lieberman et al, 2000). Colonoscopy is a diagnostic and therapeutic procedure performed to examine the inner wall of the colon for lesions and tumours. Inspection of the colon is done using a flexible endoscope, about 180cm long and 2.5cm in diameter, inserted into the patient's rectum and pushed along the length of the colon until it reaches the caecum (Figure 1). The task of navigating the endoscope in the colon is guided by the egocentric view obtained from a camera at the end of the scope. Disorientation or "getting lost" is one of the greatest problems in performing colonoscopy (Cao & Milgram, 2000, Cotton & William, 1990). Disorientation can lead to incomplete examination of the colon and missed detection of lesions, or incorrectly locating a tumour for surgery.

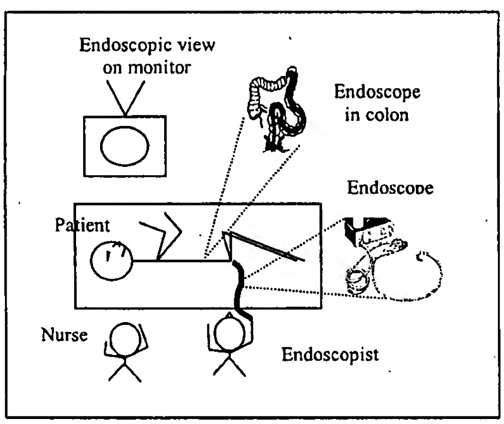

Figure 1. Colonoscopy.

Cao and Milgram (2000) reported several factors that contribute to disorientation in colonoscopy: lack of physical/motoric control and manipulability, a dearth of meaningful perceptual information, and high cognitive demands. Mechanically, the endoscopist has little control over the behaviour of the shaft of the flexible scope within the elastic and floppy colon. The scope can become twisted and entangled in the floppy sections of the colon. Perceptually, there is a lack of cues, both visual and haptic, to provide information about the progress of the procedure. There are few, and often inconsistent as well as variable, landmarks in the colon to support spatial orientation. Also, the physical length of the colon can be stretched or 'accordion-ed' over the scope such that the length of the scope inserted is not a good indication of location in the colon. Cognitively, the task of integrating the highly unreliable information available is difficult and filled with uncertainty. Navigating through the colon is a difficult skill that involves, in addition to medical knowledge and experience, spatial cognition -- being able to maintain a mental representation of the spatial relationships in the colon, and visuomotor co-ordination. Without a direct view of the colon and the endoscope, the endoscopist relies on guesswork to infer the location of the scope, or the location of a lesion. Therefore, a navigational aid designed to provide the necessary information for the endoscopist to localise and orient accurately within the colon is expected to improve the safety and outcome of the procedure. Currently, no navigational aid is available for colonoscopy.

NAVIGATIONAL AID DESIGN

Navigation and Spatial Orientation

Navigation is the process of directing the movements of a craft or ship from one point to another. Spatial orientation refers to the way one determines one's location in the environment. Successful navigation often implies being able to orient oneself within the environment (i.e., determine *where* one is *relative* to objects in the environment, and *how* one is to move amongst these objects in a particular path without

getting lost). However, it is possible to navigate and travel to the destination without knowing, along the way, where one is within the environment in a global sense. One can merely follow a set of directions using landmarks as signposts and manage to move from A to B without any sense of global orientation along the way. Therefore, spatial orientation can be performed on a local level as well as on a global level. *Local orientation,* in the *local* immediate surround, is taken here to be distinct from *global orientation*, which involves a *global* sense of position and direction.

Generally, when people acquire geographical or spatial knowledge, the amount of exposure or experience navigating through the environment determines the level of detail contained in their mental representation, or cognitive map, of the space. With initial exposure, *landmark knowledge* is acquired, which allows ego-referenced way-finding. Further experience travelling through the environment allows for development of ego referenced *route knowledge*, which is more rapid and automatic for navigation. Finally, *survey knowledge* integrates the landmark and route knowledge about an environment and represents the space as a more world referenced cognitive map (Thorndyke, 1980, cited by Wickens and Carswell, 1997). A good cognitive map allows us to determine quickly and efficiently 'where' we are, and 'how' to get to where we want to go from here.

In designing tools to support navigation, one aims to give the traveller the advantage of experience which can be gained only through extended exposure and learning through trial and error. Navigational aids can take on many different forms, from maps (paper, electronic, You-Are-Here, etc) to route lists, to signs, compass, GPS, etc. The choice of navigational aid used depends on the nature of the task goals: travel, understanding, problem solving, planning, etc. (Thorndyke & Hayes-Roth, 1982). The best tool is the one that supports the task by simplifying the cognitive transformations required (Aretz, 1991, Wickens, 1998). For example, a route list (e.g., "turn left at the stop sign, go for 2 miles, then turn right") is good for guiding travel along a path while en route, but not for a traveller who has wandered off the path and must find his way back. Similarly, a paper map of the city is good for helping the traveller understand the spatial layout of the environment and select routes for travel. However, this is only useful if the traveller can establish his own position and orientation on the map.

The requirements for the design of a navigational aid were determined based on a field study of colonoscopy (Cao & Milgram, 2000). The field study determined that, among other factors, the flexible endoscope, compounded by the non-rigid and stretchable nature of the colon, was a major contributing factor to disorientation in colonoscopy. The endoscopist's task of navigation was performed on two different levels. On the level of *local* way-finding, knowing the *local* orientation is important ("which *direction* am I heading?"). Independently, the second level concerns *global* orientation ("*where* am I in the colon?").

The key, therefore, to successful navigation in colonoscopy is to provide endoscopists with the missing information necessary to support global and local orientation, such as the location and direction of the end of the scope in the colon. Furthermore, as the configuration of the colon changes with each manipulation of the scope, the endoscopist is essentially dealing with an unstructured spatial layout. Therefore, information about the shape of the colon/endoscope should be helpful in supporting spatial orientation. This can serve to minimise uncertainty in deducing the situation, and in reducing the cognitive load required for mentally integrating the observed video images with the internal representation of the remote workspace.

Design Concept

Ideally, a 3-D global map of the colon, with a see-through view of the endoscope inside the colon would solve all the problems of localisation, orientation, untangling loops formed, and stretching the colon past its limits. Such a tool would be equivalent to continuous fluoroscopy. In the real world, a good solution would provide the critical information for maintaining spatial orientation without imposing additional processing demands on the endoscopist, and without utilising too much additional computing power. At the same time, it could be implemented without affecting patient outcome.

The optimal solution has the following characteristics. First, a fixed global "map" of position and direction in the colon would be provided to complement the egocentric view of the endoscopic image. Second, as the endoscopists all use the 2D frontal view of the colon as the common frame of reference when referring to the colon, this orientation with the head of the patient at the top of the display, the feet at the bottom, and the left side of the patient on the right side of the display, would be the most meaningful and least confusing. Third, instead of a planar view of the colon as it lies in the patient's abdominal cavity, a perspective view, as if viewed from the endoscopist's stance at the feet of a supine patient, would enhance the depth dimension of the colon within a 3D abdominal cavity. (See Figure 2a).

To obtain the position, heading, and shape information of the endoscope, a shape sensor is used. This shape sensor, the SHAPETAPE (model S1280CS), is made of a series of fibre optic sensor pairs, encased in a narrow strip of flexible spring steel and elastomers. The optical fibres are configured to measure twist and bend. There are a total of 16 pairs of sensors placed 6 cm apart along the length of the tape. Analogue sensor signals are digitised and used to calculate the position of each sensor pair relative to the first proximal pair of sensors. Thus, by coupling the SHAPETAPE to the endoscope, the position, direction, and shape of the endoscope were tracked by the SHAPETAPE in real-time. An SGI O2 workstation was used to generate a graphical model using imaging software written in C++ and OpenGL. The shape of the tape was rendered in real time as a cylindrical object with a tapered end, on a perspective grid plane (see Figure 2a). The graphics depicting the scope was rendered in cyan, while the background of the display was in grey. The display space above the grid represented the abdominal cavity (size of space and graphics were scaled to the scope and task space). Information displayed showed the beginning of scope starting at the insertion point and the length of the scope inside the colon in real-time in the display space.

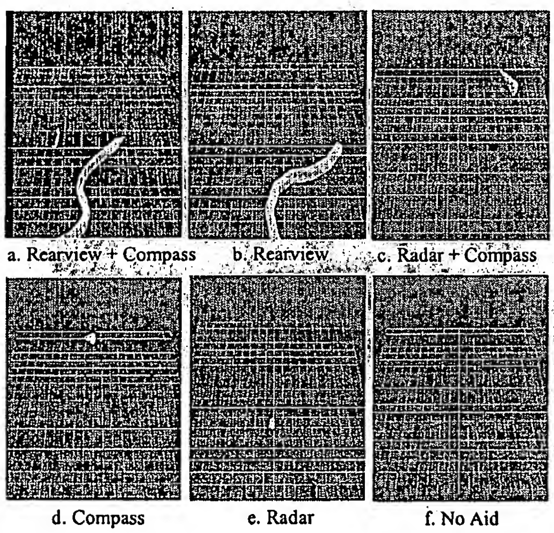

Figure 2. Navigational aid displays.

EXPERIMENT

The objectives of this experiment were two-fold. The primary objective was to evaluate the effectiveness of the display concepts for navigation and spatial orientation in colonoscopy. The secondary objective was to validate the hypothesis that shape information is critical for accurate spatial orientation in non-rigid endoscopic environments. In particular, this experiment was designed to demonstrate the relative importance of three types of spatial information for the design of a useful navigational aid: direction, location, and shape. It was hypothesised that navigation was more difficult and spatial orientation was more cognitively demanding in the non-rigid colon than the rigid colon, and that shape information was more useful than direction and location information alone in a navigational aid display for colonoscopy.

Method

Subjects. Ten subjects (3 female and 7 male graduate and undergraduate students at the University of Toronto) participated in this study. Subjects were paid $20 for their participation.

Apparatus. A mock-up of an endoscopy unit was set-up with endoscopy equipment and a simulated colon. To address the rigidity issue, a rigid and a non-rigid colon models were built and used as the task environment. Details of model construction are reported elsewhere (see Cao, 2001). The non-rigid colon model was representative of the real colon environment in visual appearance and mechanical compliance as experienced through an endoscope. The rigid colon was identical in visual appearance, but was not compliant. Their high degree of realism was validated by two expert endoscopists.

Equipment. A 180-cm diameter video colonoscope (Pentax EC-3830L), a Pentax EPM-3300 video processor and light source were used. A 27-in Sony PVM monitor was used to display the endoscopic image and the navigational aid display in a split screen. The navigational aid display was placed as an inset in the upper right hand corner of the screen.

Navigational aid displays. The original display, "Rearview +Compass" display, shown in Figure 2a, was modified to remove direction and location information to yield the following: "Rearview" display (Figure 2b), "Radar + Compass" display (Figure 2c), "Compass" display (Figure 2d), "Radar" display (2e), and "No Aid" display (2f). Each display provided varying amounts of spatial information with respect to the direction, location, and/or shape of the endoscope in real-time.

Task. The task was a modified colonoscopy procedure in the simulated colon using the endoscopic image plus one of the six navigational aid displays. Subjects were asked to guide the scope from the 'rectum' to the 'caecum' as quickly and as safely as possible, as in a real colonoscopy. Unbeknownst to the subjects, the trials always stopped when the splenic flexure was reached, even though subjects were told that the trials ended at random points during the procedure, and that no trials would reach the end of the colon.

There were two subtasks: navigation, and spatial orientation. The navigation subtask was essentially a way-finding and travel task. The spatial orientation subtask was primarily a global orientation task. Subjects were told that in addition to good performance with the scope (i.e., reach the end quickly and safely), they were required to keep track of how far they have gone in the colon. At the end of the trial, the displays were turned off and subjects were asked to indicate the location of the end of the scope inside the colon.

Experimental Design. A 2X2X6 (colon rigidity X order X display) within-subjects design was used in this experiment. Each of the 10 subjects was exposed to all 6 displays in both the rigid and non-rigid colons. The order of colon was counterbalanced. The order of display presentation for each subject in each colon condition was randomised, with no repeats of the order. Subjects were given one practice trial with the "Rearview + Compass" display. For each subject, data were collected for one trial per condition, for a total of 12 trials.

Dependent Measures. Performance measures were time to task completion, accuracy of localisation. Accuracy in localisation was measured at the end of each trial. The responses were made by marking an arrow on a pen-and-paper drawing of the colon to indicate position inside the colon. Subjective measure of confidence rating was collected at the same time. Subjects were asked to provide confidence rating for their responses on a 5-point Likert scale. A rating of 1 indicated low confidence that the location was correct, whereas a rating of 5 indicated high confidence of a correct location.

Localisation error was measured manually. The markings made by subjects on the paper drawing of a colon were converted into digital form. The individual drawings plus markings were scanned into the computer using MS Photo Editor, and digitised manually to calculate the error in absolute distance.

As for the measure of cognitive effort involved in spatial orientation, the variable used was mental workload, assessed using the standardised NASA TLX questionnaire (Hart & Staveland, 1988). At the end of each trial, subjects were asked to fill out a NASA TLX questionnaire, using all six dimensions of mental demand, physical demand, temporal demand, performance effort and frustration.

Other subjective measures included preference rankings and usefulness ratings of the navigational aid displays. At the end of the experiment, subjects ranked order their preference of the 6 navigational aid displays (from 1 to 6: most preferred to least preferred), and rated the usefulness of the displays on a scale from 0, very useless, to 10, very useful. This was followed by a debriefing session.

RESULTS AND DISCUSSION

An analysis of variance was performed on the variables of time, localisation error, workload and confidence rating.

As expected, results showed that navigation in the simulated colonoscopy task was faster when performed in the rigid colon (F=8.908, p=0.017). There was a significant order effect (F=23.149, p=0.001) and a significant order x rigidity interaction (F=9.097, p=0.017). Figure 3 shows the average task completion time for the two groups of subjects in the two colons. Subjects who started with the non-rigid colon improved upon switching to the rigid colon, suggesting that the non-rigid colon was more difficult to navigate. On the other hand, the group that started with the rigid colon showed no changes in its performance after switching to the non-rigid colon. The fact that performance did not worsen upon switching to the non-rigid colon suggests a learning effect. However, this training effect may be due to the fact that the subjects were not trained endoscopists. Nevertheless, there would appear to be a benefit in training with the rigid colon before attempting the non-rigid colon.

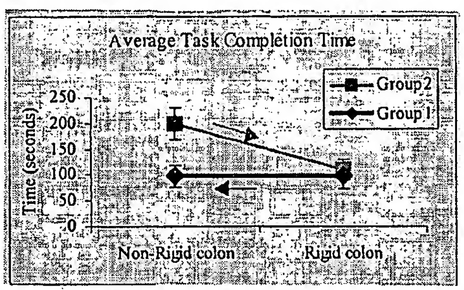

Figure 3. Task completion time. Group1 subjects started in the rigid colon; Goup2 subjects started in the non-rigid colon. Error bars are standard deviations.

Contrary to expectations, the accuracy of spatial orientation performance did not differ in the two colon conditions. However, there was a display main effect (F=3.608, p=0.009). A post-hoc Tukey multiple pair-wise comparison showed that performance using the "Rearview + Compass" display was significantly different from the "No Aid" display. Thus, localisation was most accurate using the "Rear-view + Compass" display, which provided shape, direction and location information, and least-accurate using the "No-aid" display (Figure 4). The other displays that provided a subset of the 3 spatial information were not different from one another. This suggests that for localisation in the colon, location, direction or shape alone is not enough.

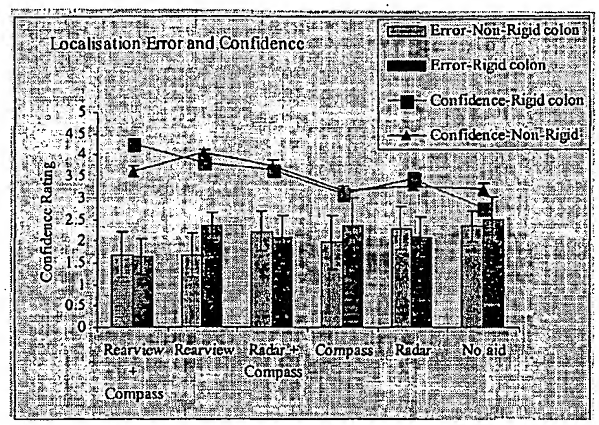

Figure 4. Localisation error and confidence rating as a function of display. The y-axis shows confidence rating scale. The y-axis for localisation is not shown. Error bars are standard deviations on the localisation measure, and standard errors for confidence ratings.

Subjects' confidence in the accuracy of their localisation was also significantly different as a function of display (F=6.973, p=0.000). A post-hoc Tukey multiple pair-wise comparison showed that confidence using the "No Aid" display was lower than all other displays except the "Radar" display and the "Compass" display. There was also an interaction between colon rigidity and display (F=3.406, p=0.012). Figure 4 shows an approximate mirror image in the correspondence between accuracy and confidence as a function of display. It suggests that as more spatial information was provided, accuracy in localisation was higher, and subjects were more confident about their spatial orientation.

Similarly, workload assessment showed no significant difference between the rigid and non-rigid colons. However, averaged over order and colon conditions, the workload measures as a function of display were significantly different (F=3.284, p=0.014). A post-hoc Tukey multiple pair-wise comparison showed that the difference was between the pair "Rearview + Compass" display and "Radar" display. This would imply that subjects found the Radar display the most difficult to use, even though it contained more information than the "No Aid" display. Most unexpected was the fact that the average workload assessed for the "No Aid" display was lower than the "Rearview", the "Compass", and the "Radar" displays (Figure 5). It is possible that while the "Rearview + Compass" display contained the most amount of information and imposed the least amount of workload, the other displays were considered more demanding to use because they lacked a 'complete' set of information when compared to the "Rearview + Compass". When information is not explicit, such as direction or location information (in the "Radar" or "Compass" displays, respectively), workload was higher than

if the information was made explicit ("Rear-view+ Compass"). Therefore, the higher workload may have resulted from trying to fill in context. Probably, the No Aid display was ignored, as it did not offer any information. Thus, the overall workload was lower as subjects did not have to devote any attentional resources to the display. Based on this analysis, it would seem that providing incomplete information is more harmful than no information at all.

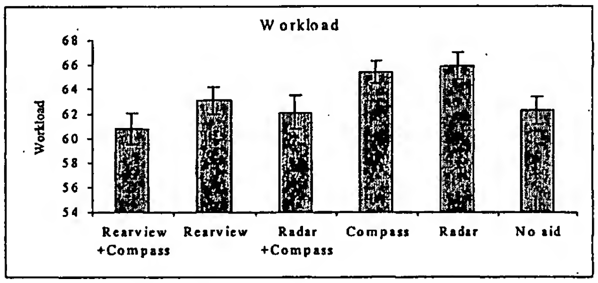

Figure 5. Workload assessment as a function of display.

This explanation is supported by the subjects' rating of usefulness for the displays (Figure 6). The "No Aid" display was rated 1 (very useless) on an 11-point scale (0 to 10), while the "Rearview +Compass" display was rated an 8. The degree of usefulness decreased as the amount of information provided decreased. It also corresponded to the order of preference for the displays (Figure 7). All subjects preferred the "Rearview + Compass" display the most, while 80% of the subjects preferred the "No Aid" display the least. One subject preferred the "No Aid" to the "Compass", while another subject preferred it to the "Radar" display.

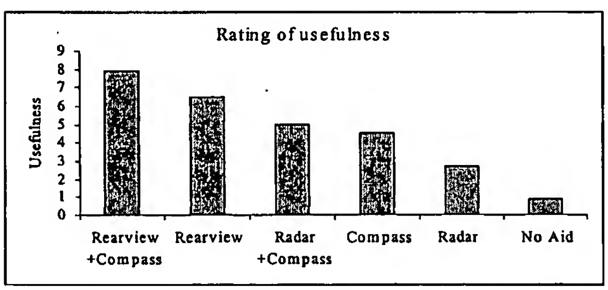

Figure 6. Rating of usefulness for displays.

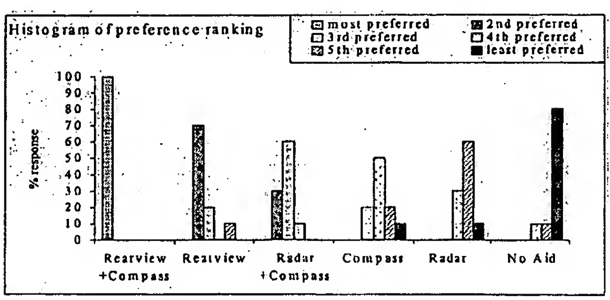

Figure 7. Histogram of preference ranking.

CONCLUSION

The results of this experiment have practical applications for the design of colonoscopy systems. The navigational aid display concept proved to be a useful one for spatial orientation in colonoscopy. Localisation errors in the colon were significantly reduced when the navigational aid provided shape information combined with location and direction information. Confidence in the localisation task was also higher with the navigational aid displays which contained shape information, and highest with all 3 (direction, location, and shape). Subjective ranking of preference and rating of usefulness indicated that more information was preferred. More significantly for future display design work is the result from workload assessment. Workload results showed that partial spatial information imposed higher workload than no information. Therefore, the minimum requirement for a useful navigational aid display in colonoscopy is to provide information of location, direction, and shape of the endoscope inside the colon. Even though the display may not help endoscopists perform colonoscopies faster, it may reduce the error and uncertainty in localising tumours.

ACKNOWLEDGEMENTS

Thank you to Paul Milgram for his guidance in this research. Funding was provided by NSERC and IRIS/PRECARN. In-kind support was provided by Measurand, Inc., Pentax Canada, and DASIE International.

The author is currently at Tufts University, Mechanical Engineering, Medford, MA.

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Computerized Medical Imaging and Graphics
Volume 24, Issue 3 , May 2000, Pages 133-151

doi:10.1016/S0895-6111(00)00014-8 Cite or link using doi

Virtual endoscopy: development and evaluation using the Visible Human Datasets

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Received 6 December 1999. Available online 30 May 2000.

Abstract

Virtual endoscopy (VE) is a new method of diagnosis using computer processing of 3D image datasets (such as CT or MRI scans) to provide simulated visualizations of patient specific organs similar or equivalent to those produced by standard endoscopic procedures. Conventional endoscopy is invasive and often uncomfortable for patients. It sometimes has serious side effects such as perforation, infection and hemorrhage. VE visualization avoids these risks and can minimize difficulties and decrease morbidity when used before actual endoscopic procedures. In addition, there are many body regions not compatible with real endoscopy that can be explored with VE. Eventually, VE may replace many forms of real endoscopy.

There remains a critical need to refine and validate VE visualizations for routine clinical use. We have used the Visible Human Dataset from the National Library of Medicine to develop and test these procedures and to evaluate their use in a variety of clinical applications. We have developed specific clinical protocols to compare virtual endoscopy with real endoscopy. We have developed informative and dynamic on-screen navigation guides to help the surgeon or physician interactively determine body orientation and precise anatomical localization while performing the VE procedures. Additionally, the adjunctive value of full 3D imaging (e.g. looking "outside" of the normal field of view) during the VE exam is being evaluated. Quantitative analyses of local geometric and densitometric properties obtained from the virtual procedures ("virtual biopsy") are being developed and compared with other direct measures. Preliminary results suggest that these virtual procedures can provide accurate, reproducible and clinically useful visualizations and measurements. These studies will help drive improvements in and lend credibility to VE procedures and simulations as routine clinical tools. VE holds significant promise for optimizing endoscopic diagnostic procedures, minimizing patient risk and morbidity, and reducing health care costs.

Author Keywords: Virtual endoscopy; Visible humans; Anatomic modeling; Volume rendering

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Computerized Medical Imaging and Graphics
Volume 24, Issue 3 , May 2000, Pages 133-151

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European Journal of Cardio-Thoracic Surgery
Volume 16, Supplement 2 , 1 November 1999, Pages S97-S105

doi:10.1016/S1010-7940(99)00281-X Cite or link using doi

Robotics and systems technology for advanced endoscopic procedures: experiences in general surgery*1

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Available online 11 November 1999.

Abstract

The advent of endoscopic techniques changed surgery in many regards. This paper intends to describe an overview about technologies to facilitate endoscopic surgery. The systems described have been developed for the use in general surgery, but an easy application also in the field of cardiac surgery seems realistic. The introduction of system technology and robotic technology enables today to design a highly ergonomic solo-surgery platform. To relief the surgeon from fatigue we developed a new chair dedicated to the functional needs of endoscopic surgery. The foot pedals for high frequency, suction and irrigation are integrated into the basis of the chair. The chair is driven by electric motors controlled with an additional

foot pedal joystick to achieve the desired position in the OR. A major enhancement for endoscopic technology is the introduction of robotic technology to design assisting devices for solo-surgery and manipulators for microsurgical instrumentation. A further step in the employment of robotic technology is the design of `master-slave manipulators' to provide the surgeon with additional degrees of freedom of instrumentation. In 1996 a first prototype of an endoscopic manipulator system, named ARTEMIS, could be used in experimental applications. The system consists of a user station (master) and an instrument station (slave). The surgeon sits at a console which integrates endoscopic monitors, communication facilities and two master devices to control the two slave arms which are mounted to the operating table. Clinical use of the system, however, will require further development in the area of slave mechanics and the control system. Finally the implementation of telecommunication technology in combination with robotic instruments will open new frontiers, such as teleconsulting, teleassistance and telemanipulation.

Author Keywords: Endoscopic surgery; Robotics; Solo-surgery; Systems; Telemedicine

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*1 Presented at the International Symposium `Present State of Minimally Invasive Cardiac Surgery – Meet The Experts', Dresden, Germany, December 3–5, 1998.

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European Journal of Cardio-Thoracic Surgery
Volume 16, Supplement 2 , 1 November 1999, Pages S97-S105

Microprocessors and Microsystems
Volume 26, Issue 4 , 2 May 2002, Pages 161-171

doi:10.1016/S0141-9331(02)00010-8 Cite or link using doi

Non-linear spatial warping of endoscopic images: an architectural perspective for real time applications

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Received 14 August 2001; revised 7 January 2002; accepted 1 February 2002. Available online 4 March 2002.

Abstract

Images captured with a typical endoscope show spatial distortion, which necessitates spatial warping for subsequent analysis. In this paper, an efficient architecture for an embedded system for the real-time correction of barrel distortion in endoscopic images is proposed. The spatial warping procedure follows a methodology based on least-squares estimation to correct the non-linear distortion in the endoscopic images. A mathematical model of polynomial mapping is used to map the images from distorted image space onto the warped image space. The model parameters include the expansion polynomial coefficients, distortion centre, and corrected centre. The spatial warping model is applied to several gastrointestinal images. The spatial warping algorithm is mapped onto a linear array of simple processing

elements with each element of a particular segment communicating with its nearest neighbours. Currently, a prototype of the VLSI architecture for an image of size 256×192 is being designed and built. The functional simulation results obtained in the warping architecture are encouraging. The VLSI based system will facilitate the use of a dedicated module that could be mounted along with the endoscopy unit.

Author Keywords: Endoscopic images; Spatial warping; Polynomial mapping

Microprocessors and Microsystems
Volume 26, Issue 4 , 2 May 2002, Pages 161-171

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Artificial Intelligence in Engineering
Volume 12, Issues 1-2 , January-April 1998, Pages 21-33

doi:10.1016/S0954-1810(96)00035-0 Cite or link using doi

Probabilistic reasoning and multiple-expert methodology for correlated objective data

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Received 19 June 1996; revised 12 September 1996; accepted 12 September 1996. ; Available online 18 June 1998.

Abstract

In this paper, a numerical expert system using probabilistic reasoning with influence structure generated from the observed data is demonstrated. Instead of using an expert to encode the influence diagram, the system has the capability to construct it from the objective data. In cases where data are correlated, instead of compromising the performance by wrestling with different influence structures based on the assumption that all the environment variables are observed, we incorporated the flexibility of including unobservable variables in our system. The resulting methodology minimised the intervention of a domain expert during modelling and improved the system performance.

Global optimisation using all variables is often very difficult and unmanageable in probabilistic network construction. In our approach, we group all the variables into subsets and generate advice for these subsets of features using multiple small probabilistic networks, and then seek to aggregate these into a consensus output. We proposed a probabilistic aggregation using the joint probability of data and model approaches. In this approach, we avoided the very high-dimensional integration over all possible parameter configurations. The resulting system has the benefit of a multiple-expert system and is easily expandable when new information is to be added.

Author Keywords: probabilistic network; bayesian inference; multiple-expert system; unobservable variables

Artificial Intelligence in Engineering
Volume 12, Issues 1-2 , January-April 1998, Pages 21-33

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Medical Image Analysis
Volume 6, Issue 3 , September 2002, Pages 321-336

doi:10.1016/S1361-8415(02)00089-0 Cite or link using doi

Tracking of a bronchoscope using epipolar geometry analysis and intensity-based image registration of real and virtual endoscopic images†*1

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Available online 30 September 2002.

Abstract

This paper describes a method for tracking the camera motion of a flexible endoscope, in particular a bronchoscope, using epipolar geometry analysis and intensity-based image

registration. The method proposed here does not use a positional sensor attached to the endoscope. Instead, it tracks camera motion using real endoscopic (RE) video images obtained at the time of the procedure and X-ray CT images acquired before the endoscopic examination. A virtual endoscope system (VES) is used for generating virtual endoscopic (VE) images. The basic idea of this tracking method is to find the viewpoint and view direction of the VES that maximizes a similarity measure between the VE and RE images. To assist the parameter search process, camera motion is also computed directly from epipolar geometry analysis of the RE video images. The complete method consists of two steps: (a) rough estimation using epipolar geometry analysis and (b) precise estimation using intensity-based image registration. In the rough registration process, the method computes camera motion from optical flow patterns between two consecutive RE video image frames using epipolar geometry analysis. In the image registration stage, we search for the VES viewing parameters that generate the VE image that is most similar to the current RE image. The correlation coefficient and the mean square intensity difference are used for measuring image similarity. The result obtained in the rough estimation process is used for restricting the parameter search area. We applied the method to bronchoscopic video image data from three patients who had chest CT images. The method successfully tracked camera motion for about 600 consecutive frames in the best case. Visual inspection suggests that the tracking is sufficiently accurate for clinical use. Tracking results obtained by performing the method without the epipolar geometry analysis step were substantially worse. Although the method required about 20 s to process one frame, the results demonstrate the potential of image-based tracking for use in an endoscope navigation system.

Author Keywords: Endoscopy; Bronchoscopy; Colonoscopy; Virtual endoscopy; Virtual bronchoscopy; Virtual colonoscopy; Image registration; Epipolar geometry; Motion recovery; Optical flow; Video image analysis; Tracking; Camera tracking

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*1 Electronic Annexes available. See www.elsevier.com/locate/media.

† A preliminary version of this paper was presented at the Medical Image Computing and Computer-Assisted Intervention (MICCAI) Conference, Utrecht, The Netherlands ([Reference to Mori et al., 2001]).

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Medical Image Analysis
Volume 6, Issue 3 , September 2002, Pages 321-336

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Medical Image Analysis
Volume 2, Issue 2, June 1998, Pages 101-119

doi:10.1016/S1361-8415(98)80006-6 Cite or link using doi

Guiding systems for computer-assisted surgery: introducing synergistic devices and discussing the different approaches

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Received 3 March 1997; revised 15 December 1997; accepted 29 January 1998. ; Available online 29 April 2002.

Abstract

Computer-assisted surgery (CAS) or computer-assisted therapy (CAT) attempt primarily to optimize the performance of medical tasks. CAS systems include a guiding system to connect the information world of data and plans to the physical world of surgeons, patients and instruments, and to supplement the surgeon's perception and dexterity. Passive, semi-active and active systems have been proposed and implemented in various clinical applications. In this paper we introduce synergistic devices which are an extension of semi-active systems.

We also discuss the advantages of the different categories of guiding systems on the basis of a list of task-oriented and user-oriented qualitative factors.

Author Keywords: computer-assisted surgery; guiding systems; medical robotics; synergistic devices

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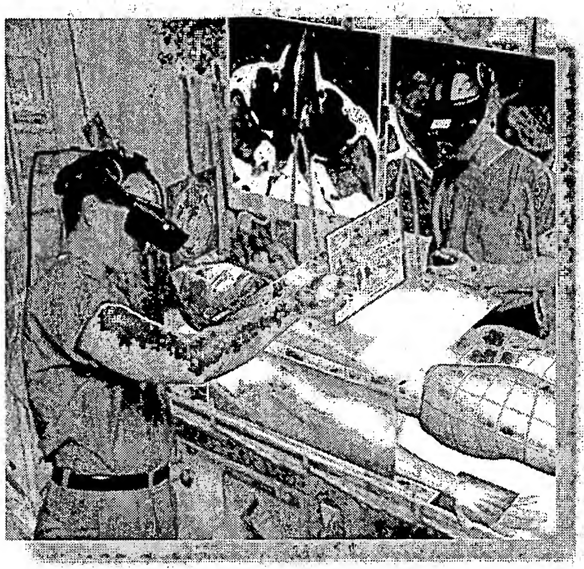
Corresponding author

Medical Image Analysis
Volume 2, Issue 2 , June 1998, Pages 101-119



OVERVIEW

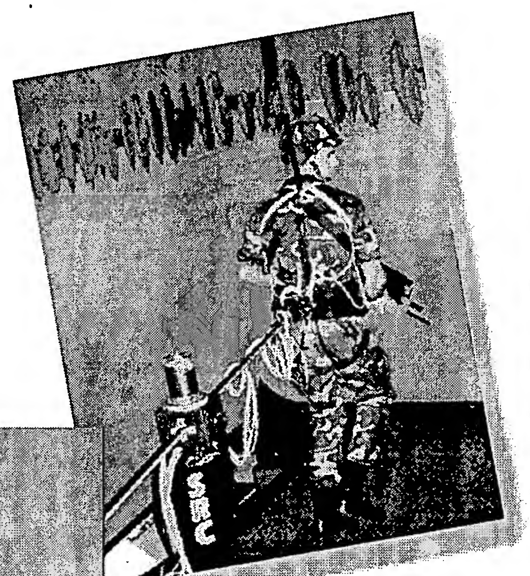
Education and Training

Current medical education and training is through traditional didactic lectures and field training. This program has explored leveraging military simulation advances into the medical domain, using VR for procedural (or partial task) training and team training, with the focus being upon combat casualty care, the medic, and the combat surgeon. The partial task training involves individual procedures or operations which a medic or surgeon must perform in lifesaving. Integration of the program has been insured by using a singular model, which is the Visible Human of the National Library of Medicine. Representative tasks that are encountered in combat casualties were chosen for simulators, matching the level of the current technologies to the ability to create a realistic simulation. Simulations are not ultra realistic but rather credible enough that the scenario is completely understood and the student can repeatedly rehearse specific procedures. Since there was no historical basis for surgical simulation, the entire program had to be created from the beginning, including the infrastructure.

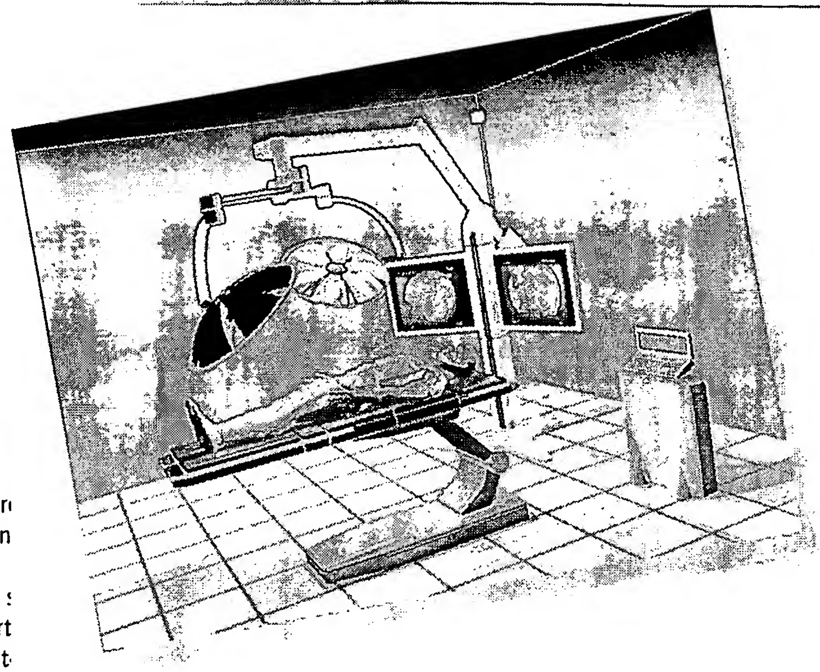
VR EDUCATION/TRAINING

Tissue properties had to be acquired and measured as by Cuschieri of the Ninewells Hospital in Dundee Scotland and Hannaford of the University of Washington. Devices were constructed by Salisbury of MIT and Hannaford of the University of Washington and Son of Pressure Profile Systems both to acquire the haptic (touch) sense from the tissue, and to be able to display that feeling back onto the hand of the student. In addition, a new way of displaying
with Dimensional Media Associates' 3-D holo
image display. For the first time, a 3-D image
space and manipulated as if it really existed.

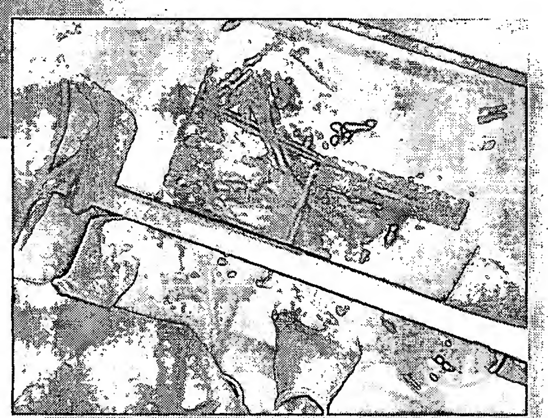
Focusing upon specific tasks for the partial ta
MusculoGraphics' Limb Trauma Simulator whi
wounding model to the Visible Human to crea
for training medics on the basic principles of
Anastomosis: Simulator of Boston Dynamics, I
basics of suturing skills. This system also inco
track the motion and pressures of the hand, s
of the manual skills of the student can be tabulated at the end of the training session. Other simulations to incorporate the skills of starting an intravenous (IV) line or performing endoscopy have been completed by HT Medical Inc. Both the Limb Trauma Simulator and the Anastomosis Simulator have completed development and are currently undergoing evaluation and testing as well as incorporation into an educational curriculum at the



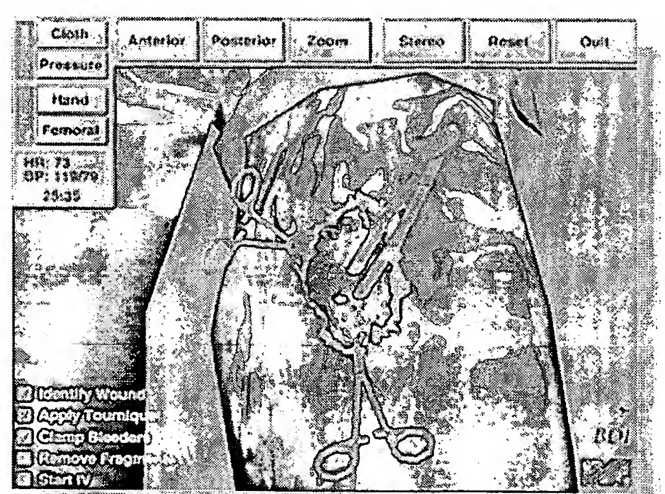
Uniformed Services University of Health Sciences (USUHS) by COL Christoph Kaufmann, MD, director of the National Capitol Area Medical Simulation Center at Forest Glen, MD. The Dimensional Media Inc. holographic display system and the tactile feedback system of Salisbury of MIT have also been incorporated into the Anastomosis Simulator for a higher level of realism.



Battlefield casualty team training requires cr ating a battlefield scenario and then insertin wounded soldiers and a medic. This effort brought the medic into the existing military s ulation network (SIMNET) as an integral part combat simulation referred to as the Simulat Corpsman (SIMCOR). Using the simulated sol (JACK) from the University of Pennsylvania with a newly created wounded soldier scenario created by Sandia National Labs and connected over SIMNET by Mike Zyda of the Naval Postgraduate School, a medic had the opportunity to participate in terrain-based battlefield training, and then practice lifesaving skills when a soldier was wounded. A preliminary attempt to incorporate the sense of smell into the environment was perfomed by Kruger of Artificial Reality Corporation, to add an additional level of realism to the battlefield. During the Association of U. S. Army annual meeting in 1997 a combined, integrated scenario was demonstrated with a medic on a treadmill using a head mounted display to view the networked battlefield. When a soldier was wounded, the medic would "run" to the side of the wounded soldier and train to give the casualty initial resuscitation. He had to identify a collapsed lung and institute proper therapy. When the patient was stabilized, the medic needed to place the casualty in a simulated life support for trauma and transport (LSTAT) to be evacuated by a helicopter. Although quite simplistic in the rendering and integration, the demonstration proved that such a large-scale team training system could be developed. These technologies are awaiting further development and improvement before undergoing testing and evaluation by the U.S. Army Center and School for combat training.

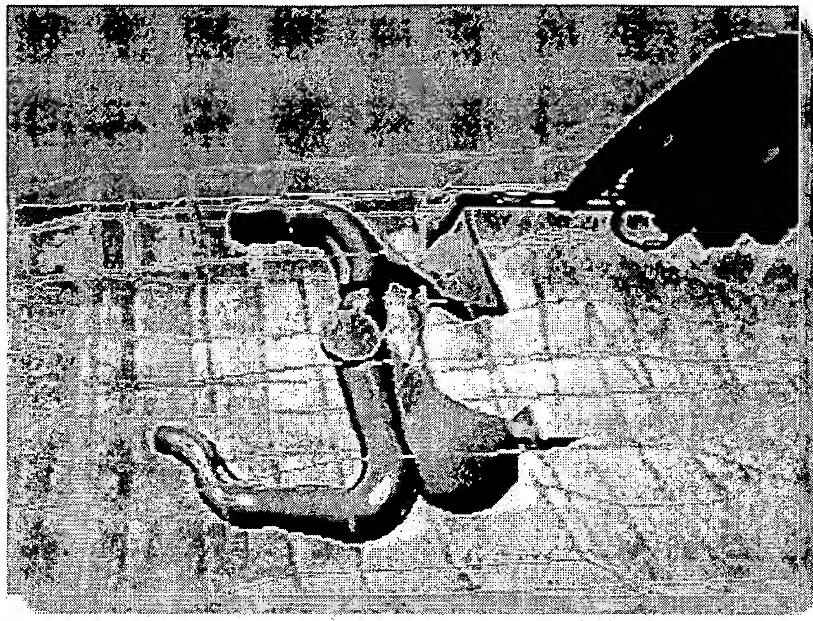


Two other interesting projects addressed the simulation of psychological and perceptual results of minimal brain injury (the DETOUR project of Addison) and the creation of an infrastructure medical education curriculum entitled virtual reality multimedia (VRMM) system by Hoffman of the University of California, San Diego. This is now transitioning to a commercial product called VisualizeR and is being incorporated into the USUHS medical curriculum.



Abdominal Surgery Simulator

A VIRTUAL Reality based Simulator of Abdominal Surgery



Project Summary

As virtual reality was emerging, the first pioneering steps for surgical simulation appeared in 1992. One of the earliest of these simulators was an abdominal simulator for cholecystectomy. During this initial Phase 1 project, individual abdominal organs were created using simple graphics programs—no other graphics tools were available. In order to create interactive 3-D simulations, an entire new programming language was created, with the commercial title "Body Electric". This initial software program was the first "object oriented programming language" for graphics. This permitted creation of objects such as individual organs or surgical instruments to be linked to one another for interactivity. The technique of "morphing" and structural deformation was to come two years after completion of the project. Contact detection algorithms combined with low resolution, low polygon graphic representations resulted in working but relatively crude simulations of organs and instruments. The frame rate was slow (12-16 frames per second) and the interactivity inaccurate, however as the first step the abdominal simulator validated the concept that virtual environments could provide a platform for surgical education.

VPL, Inc., was the first commercial virtual reality company, and introduced the first head mounted display (based upon NASA-Ames technology of McGreevy, Fisher and Ellis). VPL also created the first interactive "glove", called the "DataGlove". The abdominal simulator was a true, completely virtual reality based surgical simulator. The student wore the head mounted display and viewed the virtual organs (see above) and used the DataGlove to pick up instruments or "hold" the organs. The student could also "fly" around and through the organs (simulating endoscopy procedures), which years later led to virtual endoscopy as a clinical tool.

Technology Transfer

The company was in the process of rapid expansion when a combination of financial instability, newer emerging technologies and competing markets resulted in bankruptcy. The technology was not transferred, rather newer, more advanced imaging processing, and lighter weight and smaller head mounted displays were created by competing companies. The abdominal simulator is of great interest in the historical evolution of virtual reality for surgical simulation, pre-operative planning, and virtual diagnosis.

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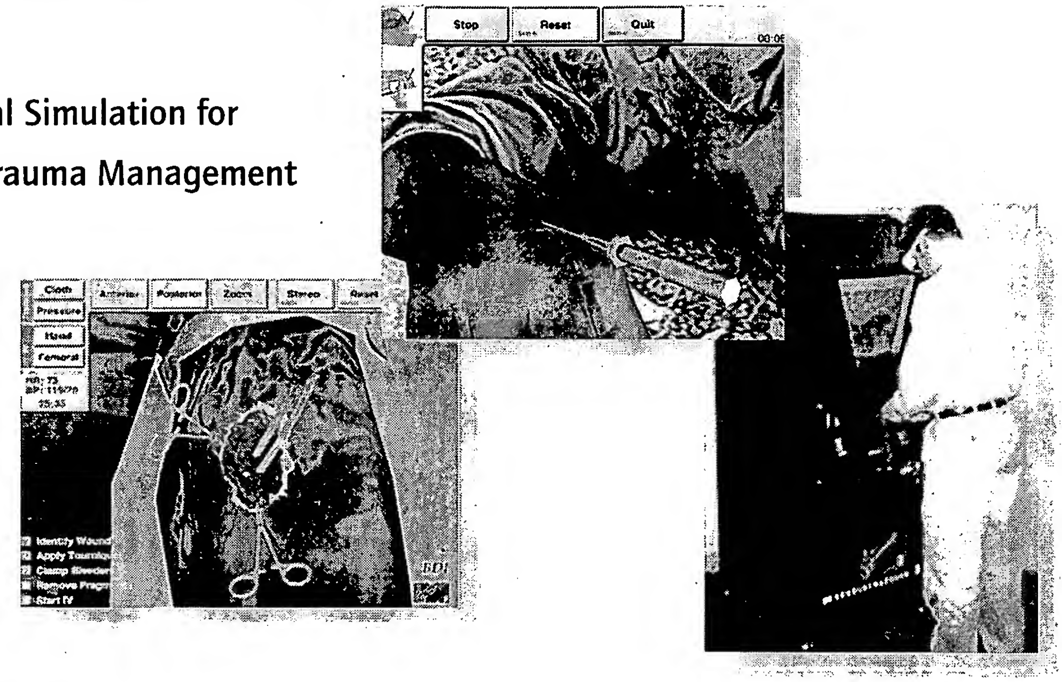
Limb Trauma Simulator

Surgical Simulation for Limb Trauma Management



Project Summary

The Lamb Trauma Management Training Simulator is designed to improve the skills and efficiency of first responders (combat lifesavers, combat medics, paramedics) and combat surgeons. The system integrates high-resolution 3-D graphics and force-feedback devices with training software that teaches fundamental trauma management skills. The system was developed for the U.S. Army as a realistic alternative to animal-based and cadaver-based training, and to augment traditional field training.

3-D computer models of the human anatomy are at the core of the training simulator. The system also includes a set of virtual surgical instruments–forceps, hemostats, and intravenous (IV) catheters–that let students manipulate and interact with the simulated casualty to learn and practice trauma management techniques. The physics-based elasticity and bleeding algorithms incorporated with the computer models add realism to the simulator by mimicking the behavior of human tissue.

The current version of the simulator models a gunshot wound to the leg. In this training scenario the student must characterize the extent of the gunshot injury and control any bleeding by clamping blood vessels. Next, the student inserts an IV catheter into the casualty to replenish the patient's fluids. The student must also identify and remove shrapnel and loose bone fragments from the wound. At the end of the simulation, the computer evaluates the student's performance and displays the final score and elapsed time.

Technology Transfer

Four training simulators were developed for this contract. One was delivered to the Special Operations Medical Training Center at Ft. Bragg, NC. Two were delivered to the Uniformed Services University of the Health Sciences in Bethesda, MD. One unit remains at MusculoGraphics to support the three units in the field. The company is currently looking for partners to commercialize the system.

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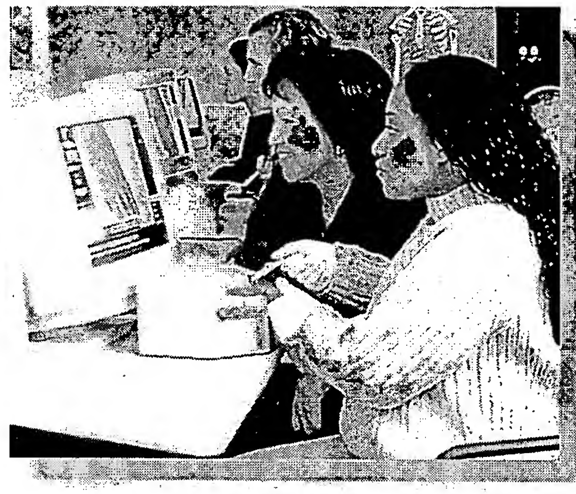
IV & Bronchoscopy Simulator

Simulation Assessment for Surgical Trauma



Project Summary

There is a need to train medics, physicians, and other healthcare providers in the basic skills for combat casualty care and for the fundamental procedures needed in diagnosis and treatment of traumatic injury. In the past, medical procedural training involved learning on the job (putting the patient at risk). Virtual reality (VR) technology offers medical personnel the opportunity to practice in an environment where mistakes do not adversely affect patients.

HT Medical Systems set out to develop innovative surgical simulation technology. The project advanced the overall medical simulation industry through in-depth study of real-time computer-based deformable objects, simulated cutting and bleeding, and tactile feedback robotics. HT Medical Systems transferred breakthroughs in these technologies to the development of simulation products that are advancing training in both military and civilian healthcare. These simulators cover three procedural areas; vascular access, endoscopy, and endovascular therapies.

The use of this technology on an ongoing basis will help maintain skills and provide a basis for evaluation of quality of care. Enhancements in training and evaluation have the potential to save significant costs by reinforcing best practices. (This technology improves outcomes, reduces waste, and improves morbidity and mortality.)

Technology Transfer

This project provided the initial opportunity to develop surgical simulation and create the first commercial surgical simulation software. HT Medical Systems' simulator products are currently being used worldwide in both military and civilian facilities to train medical personnel. The first of these simulators were installed in the National Capital Area Medical Simulation Center of the Uniformed Services University of Health Sciences (USUHS) in Forest Glenn, MD. Systems are commercially available from HT Medical Systems; Gaithersburg, Maryland, U.S.A.

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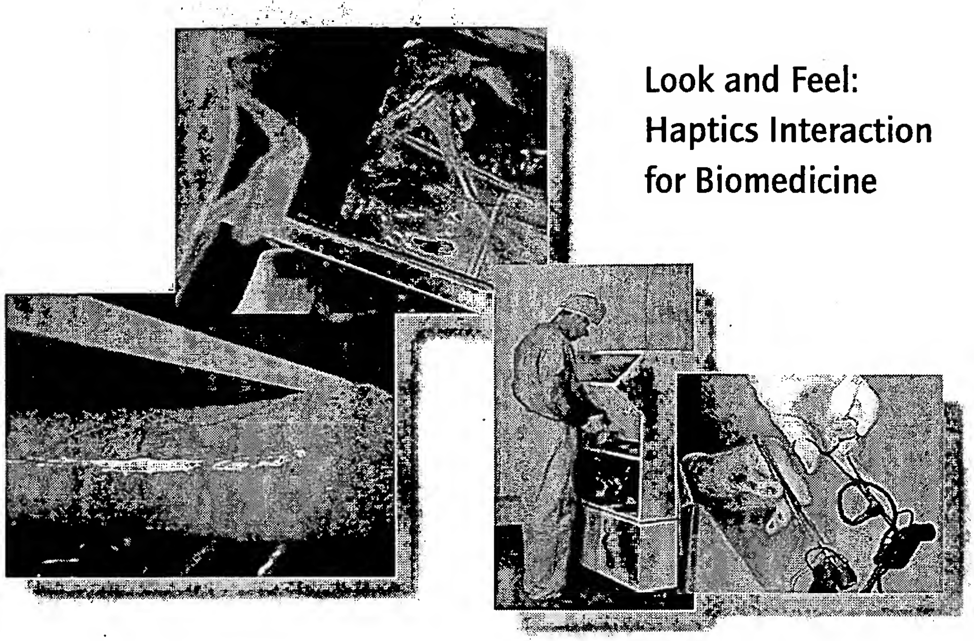
Anastomosis Simulator

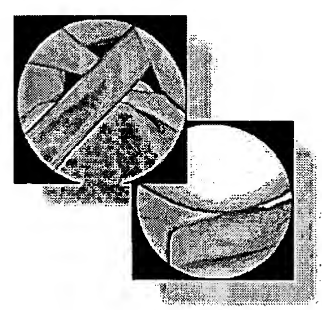


Look and Feel: Haptics Interaction for Biomedicine

Project Summary
Combat surgery requires a high level of technical and cognitive skills. Current training methods require the use of animal or cadaveric models, or actual training on patients. In order to provide basic skills training, an anastomosis simulator was created. This required the incorporation of high-resolution graphics, fully interactive 3-D modeling with tissue interaction, provision of the sense of touch through the use of a novel haptics interface called the Phantom, and intelligent software to track hand motions and provide an objective assessment of the manual dexterity of the student. A second simulator to train in arthroscopic procedures was developed based upon the programming and haptics infrastructure developed for the anastomosis simulator. They have built high performance training simulators for vascular anastomosis, knee arthroscopy, catheter insertion, wound debridement, and vascular stent placement.

Anastomosis Simulator
The Boston Dynamics Anastomosis Simulator lets you see, touch, and feel real-time simulated vessels. It is used to practice curved needle suturing technique. Simulated vessels move realistically in response to manipulation and suturing. The system quantifies performance and delivers a "Surgical Report Card". A skill assessment study reporting testing of the simulator appears in the Journal of the American College of Surgeons, July 1999.

Knee Arthroscopy Simulator
Working with the American Board of Orthopaedic Surgery, Boston Dynamics developed a simulator for arthroscopy of the knee. The user surveys the interior of the knee using standard techniques that require coordinated manipulation of the knee, hip and arthroscope. Force feedback quides interactions between the arthroscope and tissues of the knee joint. The system provides damaged tissues to test the user's ability to detect abnormalities.



Technology Transfer
Boston Dynamics offers the leading interactive surgical simulators. It was the first company to combine quantitative surgical skill assessment with rich computer graphics, and high-performance force feedback. Boston Dynamics has worked with a range of customers, including medical device manufacturers, the American Board of Orthopaedic Surgery, Hershey Medical Center, and others. Simulators are available directly from the company.

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Sinusoscopy Simulator

The ENT Surgical Simulator Project

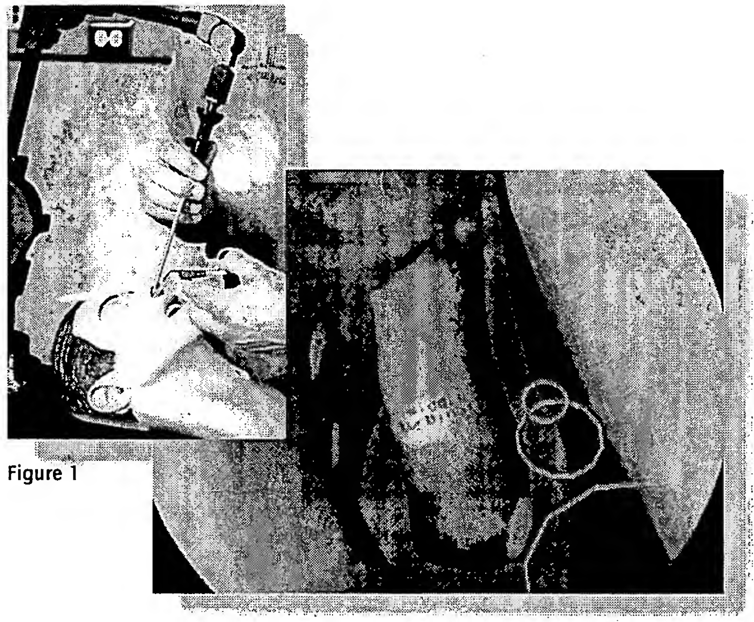

Figure 1

Project Summary

Lockheed Martin's endoscopic sinus surgery (ESS) simulation trainer, an electro-mechanical, software-driven mannequin (Figure 1), re-creates an operating room environment to simulate a procedure and stimulate the learning process at many experience levels. This hybrid mannequin and virtual anatomy simulator incorporates an intelligent tutoring database. The images are displayed upon the monitor in a virtual reality (VR) interactive environment. This responsive simulation trainer challenges users as they evaluate new techniques, handle instruments, and review anatomy.

As a challenging and potentially risky procedure, endoscopic sinus surgery is a prime candidate for VR simulation training. The ESS simulator is a collaboration of Lockheed-Martin (formerly Loral Training and Simulation), the Ohio Supercomputer Center, and Immersion Corp., under the direction of Major Chuck Edmond, an otolaryngologist at Madigan Army Medical Center and a Human Interface Technology Lab (HIT Lab) medical advisor.

Practicing surgeons and surgical interns take hold of instruments and conduct a sinus surgery procedure. They feel the anatomy via tactile feedback through selected instruments. They view, from the perspective of the endoscope, the selected surgical instrument as it manipulates or dissects the interactive patients's tissue. They hear the patient's heart rate respond to the effects of drug injection. Using the VR simulator, a trainee will progress from a simplified "novice" task aimed at training basic endoscope navigation and instrument skill, through a more complex anatomical model enhanced with visual and auditory cues (the "intermediate" level), to an unassisted simulated procedure (the "expert" level). All trials are automatically scored by the system and can be replayed for further feedback and instruction.

The virtual patient models accurately represent human sinuses (Figure 2), which were derived from the National Library of Medicine's Visible Human Project. In addition to standard models, instructors can select from anatomical variants such as paradoxical turbinate, concha bullosa, deviated septum, and polyps.

The HITLab team evaluated the utility of the haptic display and of the visual and auditory training aids, the correlation between performance on the simulator and performance in the operating room, and the relative impact of experience with the simulator on various components of surgical skill.

Technology Transfer

The Endoscopic Sinus Surgery Simulator was developed as a Technology Reinvestment Project with full participation and cost sharing with Lockheed Martin. It is now a commercial product available from Lockheed Martin.

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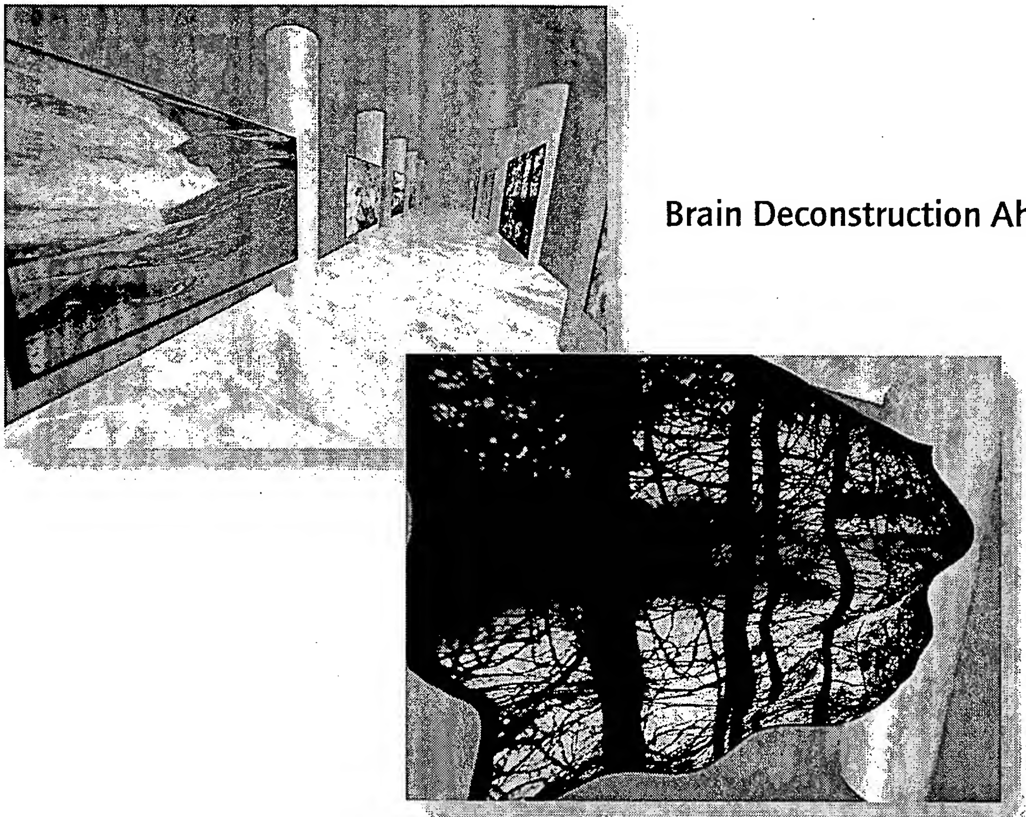
DETOUR



Brain Deconstruction Ahead

Project Summary
Artist Rita K. Addison and partner, artist, and programmer Marcus Thiebaux tell the true story of how a car accident left Rita with brain damage and a sense of desolation which she soon discovered was shared with many other traumatic brain-injured survivors. She proposed to Electonic Visualization Laboratory (EVL) of the University of Illinois that virtual reality might be just the medium in which to attempt an experiential walk through of altered perceptions, including visual, auditory, and balance distortions. Addison relates "My goal was to evoke empathy for those with seemingly invisible injuries, i.e., brain trauma changes one's life forever, yet to an onlooker there are no visible casts for broken bones, no bandages, no obvious stitches holding together a broken brain." Audiences around the world have responded positively to the award-winning DETOUR and it has been heralded as a breakthrough application in combining a very personal story of physical and psychological trauma with the most advanced computer technology available today.

Technology Transfer
Rita and David Zeltzer are currently developing a commercial product, "Empathy Learning Virtual Environment System"(ELVES). They continue to lecture and publish about DETOUR and their related work. DETOUR was created and presented in the CAVE at SIGGRAPH '94 and is now a permanent installation at the CAVE at the National Center for Supercomputing Applications (NDXA) in Illinois.

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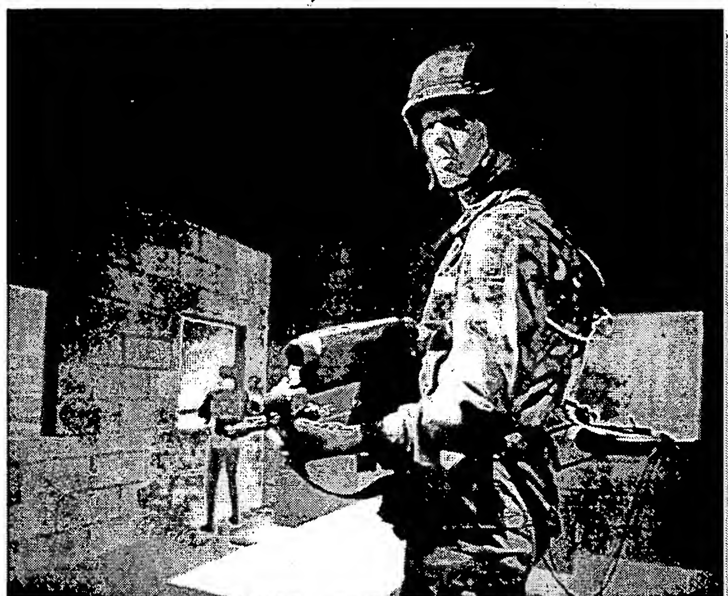
SIMCOR

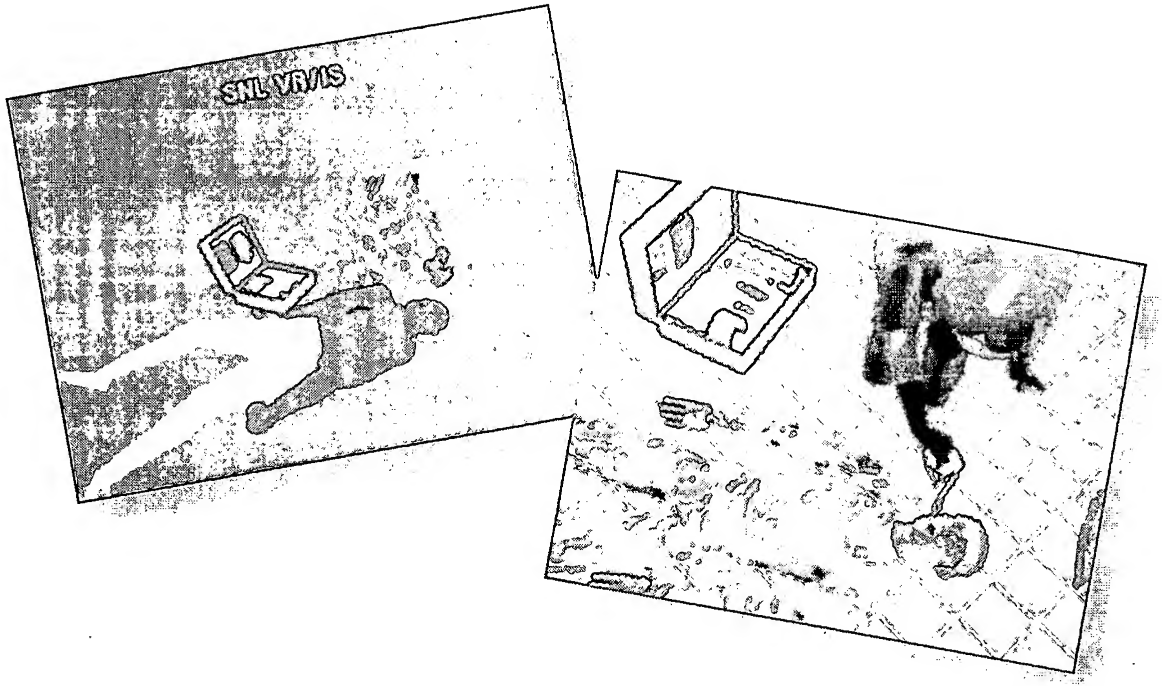
The Simulated Corpsman for Medical Forces Planning and Training



Project Summary

SIMCOR is targeted primarily at training battlefield medical personnel whose responsibility is to triage and stabilize multiple casualties for evacuation to field hospitals where patients will receive focused medical care. This focus differentiates SIMCOR from other VR-based medical trainers whose primary goal is to train a specific procedure or task. Such systems provide highly realistic anatomical visualizations and/or multi-modal interfaces that address the visual and haptic cues involved in carrying out specific procedures utilizing appropriate medical instruments. The goal of the SIMCOR trainer, in contrast, is to train rapid situational assessment and decision making under highly stressful conditions. Thus, SIMCOR looks to train the medic not to insert an IV, but rather to understand the circumstances under which an IV is required. The former is referred to as task training, while the latter is referred to as situational training. The adage "practice makes perfect" is quite apropos to situational training. Lectures, books, videos, etc. are no substitute for hands-on-experience—we often learn more from our mistakes than from our successes. Unfortunately, it is difficult to provide such training for large-scale emergency medicine. Current methodology is to use live training exercises: medics practice stabilization and wound care on animals (e.g. producing a gunshot wound in a goat) or via moulage (a training exercise where live soldiers are given highly realistic "fake" wounds). The shortcoming with the latter is that the medic does not get to practice wound care, while with the former it's the growing concern over using animals for such purposes. Virtual Reality has the potential to augment current training by providing a dynamic, hands-on simulation of a battlefield environment with casualties that both manifest the physiology of a given wound dynamically over time and who also respond, positively or negatively, to the medic's actions.

SIMCOR is a prototype Virtual Reality system developed by Sandia National Laboratories to support training/rehearsal for battlefield medics and other emergency first responders. SIMCOR immerses the trainee in a high resolution synthetic environment consisting of a virtual world, consisting of the participants, and virtual casualties. Each participant wears a VR head-mounted display and a set of position trackers that permit him to view and interact with the virtual world. The system also has a voice recognition capability. Multiple participants may share the simulation via a local area network (LAN) utilizing standard multicast protocols. Open-sourced multicasting was developed by the Naval Postgraduate School (NPS) to support a fully networked, distributed interactive virtual environment called NPSNET-IV. Participants are represented within the VE as full graphical figures called Avatars. These avatars provide a high fidelity representation of the actions and motions of the participants. The simulation itself consists of several components. Casualties are modeled using virtual humans who manifest the symptoms of the injuries being modeled as well as the changes brought about by the intervention of the trainee. The trainee must assess and stabilize the casualty. If the



diagnosis is incorrect, if the wrong procedures are performed, or if the trainee is not fast enough, the casualty will die. Researchers at the University of Pennsylvania developed the initial tension pneumothorax injury model. Head trauma injury models have subsequently also been developed. BioSimMER, also funded by DARPA, is an extension of SIMCOR to multiple casualties and a bio-terrorism scenario. Trainees are presented with agent exposure casualties and psychological trauma in addition to conventional injuries. Two additional capabilities were briefly explored for the SIMCOR project. The first was the integration of the high fidelity SIMCOR trainer into the larger, but lower fidelity, Distributed Interactive Simulation (DIS) simulation environment used by the military for training large-scale actions, such as the Dismounted Warrior Battle Labs at Ft. Benning, GA. The second was to show a proof-of-concept demonstration utilizing the simulation environment to explore the use of prototype medical devices before a functioning real-world device is built.

Technology Transfer

The virtual environment system of Sandia National labs has undergone human performance evaluations at the National Emergency Response and Rescue Training Center in College Station, TX, and will be fielded in FY00. The University of Pennsylvania's JACK virtual avatar software for the medical simulation is now commercially licensed by Engineering Animation, Inc., and is used worldwide for human figure animation and human factors analysis. NPSNET-IV and the papers associated with that project remain on our web site although we are no longer funded by anyone to continue working with that source code. The project did allow us to collect knowledge about networking virtual environments such that we could produce a book "Networked Virtual Environments—Design and Implementation," ACM Press, July 1999. That book is the major work on net-VEs.

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I-Port

Individual Portal into the Virtual Battlefield

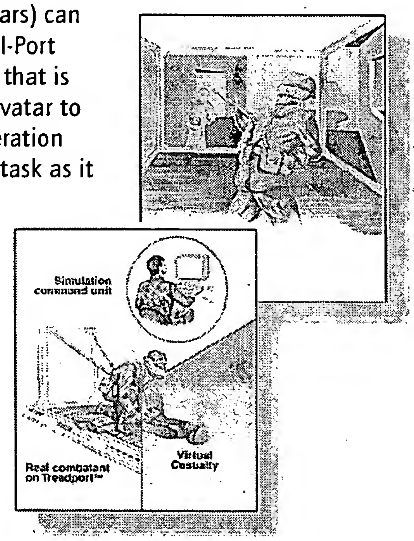

Figure 1


Figure 2

Project Summary

There is a need to train medics in battlefield triage and casualty care in an environment that contains the stress and "fog of war", known as situational training. Virtual environments, such as SIMCOR, are being created that have the potential to augment current training by providing a dynamic, hands-on simulation of a battlefield environment with casualties that both manifest the physiology of a given wound dynamically over time and who also respond, positively or negatively, to the medic's actions.

I-Port is a suite of mechanical display systems in which human-like icons (avatars) can be driven through the environment using hands-off user steerable navigation. I-Port provides resistance proportional to the rate of travel, slope, the type of terrain that is being crossed, and the type of task being performed. The system permits the avatar to assume a kneeling and prone position, and provides realistic feelings of acceleration for walking, running, and crawling. I-Port meters exertion in proportion to the task as it would be performed in the real world, allowing military tradeoffs between risk and work. The system is compatible with the NPSNET simulation networking software, allowing several soldiers and medics to enter the same virtual environment, see body postures, locomotion, hand/arm signals and casualty scenarios. This offers new possibilities to insert the warrior into the virtual battlefield for the purpose of simulation-based design, workspace evaluation, exercise, training, and rehearsal and performance assessment. The system is available in a number of different configurations: the UniPort unicycle style interface (Figure 1), a Tread-Port unidirectional flat surface (Figure 2), and individual Soldier Mobility Simulator (ISMS) similar to a stepping exerciser.



Technology Transfer

The I-Port was demonstrated at the Association of the United States Army (AUSA) annual meeting in 1997. It is available as a commercial product from Sarcos, Inc.

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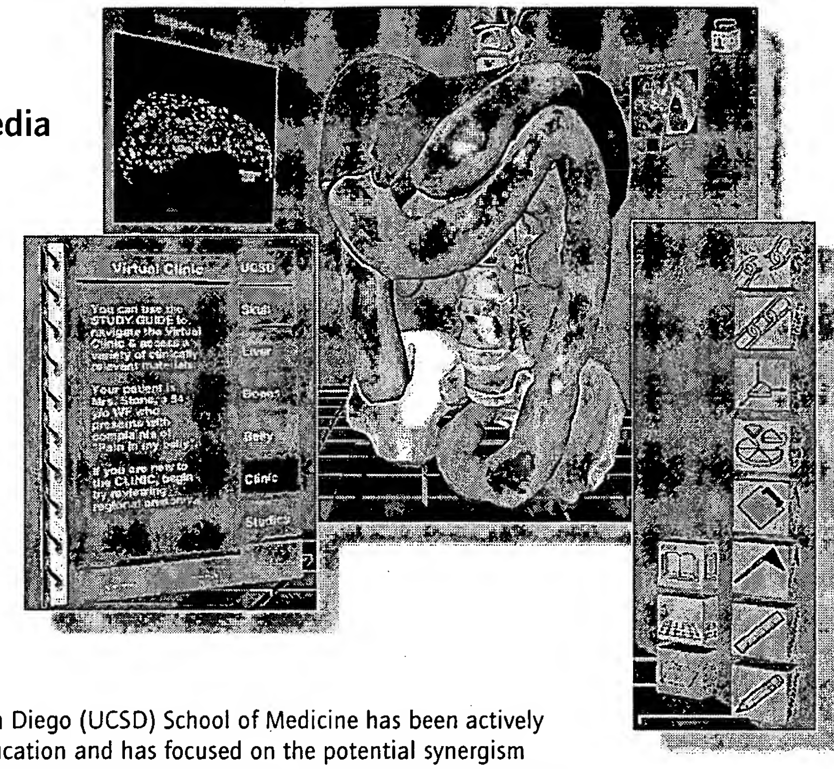
Virtual Reality Multi-Media

Virtual Reality/Multimedia Synthesis, Phase II: Prototyping and System Evaluation



Project Summary

The University of California San Diego (UCSD) School of Medicine has been actively exploring the role of VR for education and has focused on the potential synergism arising from combining VR with traditional curricular resources. This research and development effort has produced "Anatomic VisualizeR", a multimodal 3-D environment where VR serves both as the lesson core and as the interface to diverse learning resources and reference materials. The program provides an intuitive virtual workspace where students are able to "dissect" 3-D anatomic models while accessing a broad range of supporting resource elements (diagrams, images, text, video, MEDLINE, etc.). Anatomic VisualizeR includes a faculty-authored Study Guide which provides key concepts, suggested exercises, and links to a wide variety of clinical correlates and contextually-linked domains of medical science (histology, pathology, radiology, etc.). It can support lessons which are case-based, anatomy dissector-based, or a mixture of both. The Study Guide, as well as Toolbars, provide the syntax for users to navigate, manipulate, and interact with the application and its resources. A broad range of virtual exploratory tools and options are available which enable users to investigate structures in ways not possible in the real world. Students are able to repeatedly "dissect" structures and regions, or to reconstruct any area from its component parts. The options available to users include: link/unlink models, change opacity or size, dynamically create cross-sectional views using a clipping plane, measure sizes and distances with a virtual ruler, label structures with a flag marker, identify structures using a probe tool, and draw lines and simple objects using a Space Draw tool. Anatomic orientation can be maintained regardless of view or magnification and anatomic position reestablished through a Toolbar option. Anatomic VisualizeR is based on the UCSD's VisualizeR architecture and thus can support multiple types of visual display (monoscopic CRT, stereoscopic CRT, and full-immersion) and input options (gloves, 3-D trackball, and mouse). Anatomic VisualizeR currently utilizes models derived from the NLM's Visible Human dataset, but it is capable of utilizing a variety of other 3-D polygonal models as well. .

Technology Transfer

Anatomic VisualizeR learning modules have been successfully piloted by both high school and medical school students. With commercial or grant support, Anatomic VisualizeR will be able to complete the transition from prototype to product. In addition, multiple spin-offs of the underlying architecture are being considered, including a multi-user, collaborative version of VisualizeR configured for use on the Internet. The final prototype is undergoing testing, evaluation, and validation at the Uniformed Services University of Health Sciences (USUHS).

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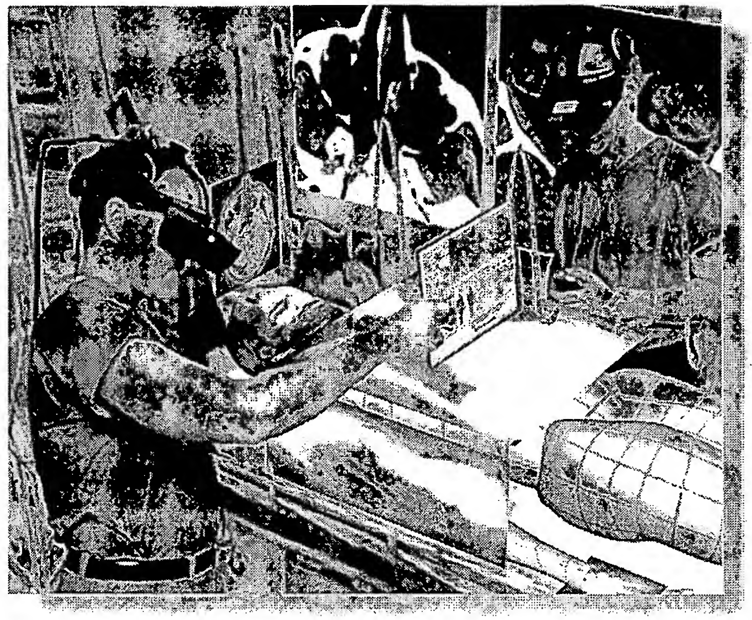
Virtual ER



Advanced Human Interfaces for Telemedicine: The Virtual Emergency Room

Project Summary

The emergence of the electronic patient record will radically change the way clinical information is accessed and used. At the same time, new technologies for displaying and interacting with data are emerging in various markets. Wearable computers with wireless data links can provide mobile access to the patient record. See-through head-mounted displays and voice recognition systems provide hands-free interaction, and in combination with viewpoint position tracking, can enable augmented reality overlay of data onto objects in the world. Handheld "ubiquitous computing" devices, such as wireless tablet terminals, PDAs and large-scale flat screens, also expand the universe of possibilities for clinical data interaction.

The Virtual Emergency Room at the University of Washington's HIT Lab (Human Interface Technology laboratory) was created as a tool for exploring the many possible ways of displaying and interacting with the electronic patient record in the clinical environment of the future. In the Virtual ER, physicians are immersed in any of several simulated clinical settings, and they are free to grab and place data objects in the environment while performing a clinical task. Data objects range from simple images to live numeric and image data streams. Placement can be "stabilized" with respect to the patient, the room, the physician's body, or the physician's field of view. Novel data representations and interaction techniques can also be simulated and tested for their ease of use and clinical utility. One extension of the Virtual ER is currently being used to train surgical residents in the proper placement of instrument ports for various laparoscopic procedures. Another has been used to test the viability of a 3-D technique for displaying EKG data.

Technology Transfer

While the Virtual ER is not intended to be commercialized directly, it does provide a design environment and testbed for a variety of clinical products, in addition to clinical informatics software and interface methods. User interfaces to a variety of clinical devices can be simulated, along with candidate device form factors. Experiences of physicians in the Virtual ER can also be used to suggest new directions for future clinical product development. Research sponsors and product development partners are being sought to utilize and expand the capabilities of the testbed.

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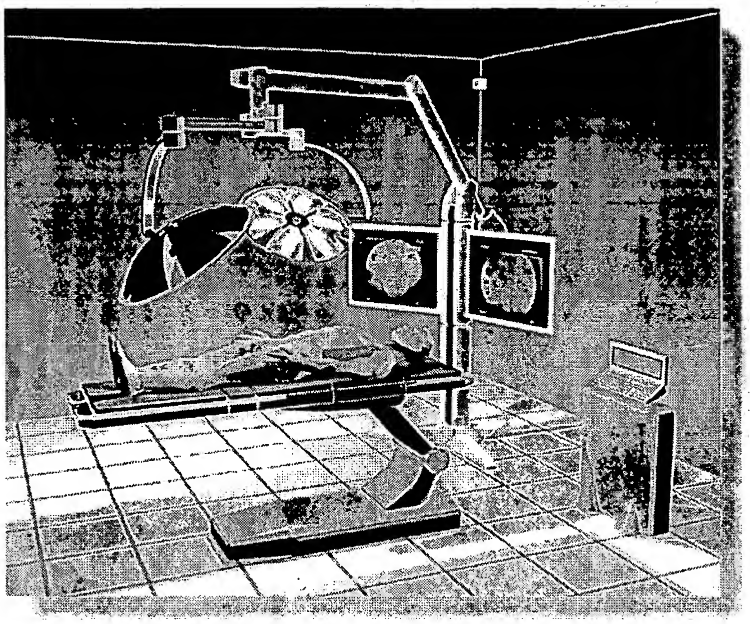

Operating Environment of the Future

Project Summary

The purpose of the OEF project was to develop the next-generation, multi-platform, tri-service military integrated medical environment. The scope of the project encompassed three principal systems within the OEF: 1) the Intuitive Display and Command System (IDACS) providing real-time information management through integrated displays, hands-free interface, local / remote connectivity, and a wireless, multi-media environment; 2) the Smart Surgical System (SSS) integrating physiological sensors with the surgical platform, incorporating advanced materials, and optimizing ease-of-use, mobility, and deployability; and 3) the Intelligent Virtual Patient Environment (IVPE) employing modified actual surgical instruments and a simulated patient for the improvement of surgical skills, training in battlefield procedures, and automation of performance measurement.

The results of this initial phase were demonstrated to DARPA, and included: (1) a real-time video image of the Smart Surgical System surgical table and separately generated graphical images of a patient heart rate trace were combined by IDACS and wirelessly transmitted for display on a large screen monitor; (2) stored patient data (including heart rate, temperature, and blood pressure), transmitted wirelessly from the IDACS to the large screen monitor; (3) a mock-up of a body-worn Surgeon Interface Unit (SIU) with a stereo see-through visor display, stereo audio, speaker-independent voice recognition, wireless voice/video receiver, and wireless data transceiver; (4) a hands-free command-and-control capability, demonstrated in re-positioning the video camera above the Smart Surgical System surgical table and in calling up archived patient data for display on IDACS monitors and (5) developing software to filter and interpret acoustic signals from the Smart Surgical System to provide the current heart rate and associated waveform on IDACS monitors. During the demonstration, this capability was demonstrated using a handheld acoustic sensor.

Technology Transfer

Progress was demonstrated on the other two components of the OEF, as well. For the Smart Surgical System, a conformal antenna was used to wirelessly transmit the signal from the acoustic monitor embedded in the composite surgical table. For the Intelligent Virtual Patient Environment, cognitive abilities associated with endoscopic surgery were identified, as were initial voice-recognition and anesthesia requirements, and a front-end requirements generation and analysis "decision support system" software tool was developed (essentially a high fidelity, qualitative and quantitative relational database).

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Medical Image Analysis
Volume 2, Issue 2 , June 1998, Pages 121-132

doi:10.1016/S1361-8415(98)80007-8 Cite or link using doi

Volumetric object modeling for surgical simulation

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Received 3 March 1997; revised 7 July 1997; accepted 11 September 1997. ; Available online 29 April 2002.

Abstract

Surgical simulation has many applications in medical education, surgical training, surgical planning and intra-operative assistance. However, extending current surface-based computer graphics methods to model phenomena such as the deformation, cutting, tearing or repairing

of soft tissues poses significant challenges for real-time interactions. This paper discusses the use of volumetric methods for modeling complex anatomy and tissue interactions. New techniques are introduced that use volumetric methods for modeling soft-tissue deformation and tissue cutting at interactive rates. An initial prototype for simulating arthroscopic knee surgery is described which uses volumetric models of the knee derived from 3-D magnetic resonance imaging, visual feedback via real-time volume and polygon rendering, and haptic feedback provided by a force-feedback device.

Author Keywords: surgical simulation; volume graphics; volumetric modeling

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Medical Image Analysis
Volume 2, Issue 2 , June 1998, Pages 121-132

In Proc. of SPIE Vol. 3660, Physiology and Function from Multidimensional Images, Medical Imaging 1999.

Automated Endoscope Navigation and Advisory System from medical imaging

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ABSTRACT

In this paper, we present a review of the research conducted by our group to design an automatic endoscope navigation and advisory system. The whole system can be viewed as a two-layer system. The first layer is at the signal level, which consists of the processing that will be performed on a series of images to extract all the identifiable features. The information is purely dependent on what can be extracted from the 'raw' images. At the signal level, the first task is performed by detecting a single dominant feature, lumen. Few methods of identifying the lumen are proposed. The first method used contour extraction. Contours are extracted by edge detection, thresholding and linking. This method required images to be divided into overlapping squares (8 by 8 or 4 by 4) where line segments are extracted by using a Hough transform. Perceptual criteria such as proximity, connectivity, similarity in orientation, contrast and edge pixel intensity, are used to group edges both strong and weak. This approach is called perceptual grouping. The second method is based on a region extraction using split and merge approach using spatial domain data. An n-level (for a 2^n by 2^n image) quadtree based pyramid structure is constructed to find the most homogenous large dark region, which in most cases corresponds to the lumen. The algorithm constructs the quadtree from the bottom (pixel) level upward, recursively and computes the mean and variance of image regions corresponding to quadtree nodes. On reaching the root, the largest uniform seed region, whose mean corresponds to a lumen is selected that is grown by merging with its neighboring regions.

In addition to the use of two-dimensional information in the form of regions and contours, three-dimensional shape can provide additional information that will enhance the system capabilities. Shape or depth information from an image is estimated by various methods. A particular technique suitable for endoscopy is the shape from shading, which is developed to obtain the relative depth of the colon surface in the image by assuming a point light source very close to the camera. If we assume the colon has a shape similar to a tube, then a reasonable approximation of the position of the center of the colon (lumen) will be a function of the direction in which the majority of the normal vectors of shape are pointing. From the above, it is obvious that there are multiple methods for image processing at the signal level.

The second layer is the control layer and at this level, a decision model must be built for endoscope navigation and advisory system. The system that we built is the models of probabilistic networks that create a basic, artificial intelligence system for navigation in the colon. We have constructed the probabilistic networks from correlated objective data using the maximum weighted spanning tree algorithm. In the construction of a probabilistic network, it is always assumed that the variables starting from the same parent are conditionally independent. However, this may not hold and will give rise to incorrect inferences. In these cases, we proposed the creation of a hidden node to modify the network topology, which in effect models the dependency of correlated variables, to solve the problem. The conditional probability matrices linking the hidden node to its neighbors are determined using a gradient descent method which minimizing the objective cost function. The error gradients can be treated as updating messages and can be propagated in any direction throughout any singly connected network to adjust the network parameters. With the above two-level approach, we have been able to built an automated endoscope navigation and advisory system successfully.

Keywords: Probabilistic Network, Bayesian Inference, Unobservable variables, Shape from Shading, Region Segmentation, Armijo's rule.

1. INTRODUCTION

An endoscope is a medical instrument used for observing the inner surfaces of the human body. Particularly, it is used for diagnosing different upper gastrointestinal (UGI), colon and bronchus diseases. Different types of endoscopes are widely used in medical institutions all over the world as an alternative to exploratory surgery. However, navigating an endoscope in the human body requires a great deal of skill and experience.

Navigation of an endoscope inside the human colon is a complex task. The endoscope behaves like a chain of articulated rods being pushed at the rear end into a highly flexible tube-like UGI or colon with many bends, twists and pockets. For instance during colon endoscopy, the endoscope tip is introduced into the rectum and is gradually advanced through the large intestine. When it bears on colon walls it may distort its shape and produce paradoxical behaviors around the tip. The colon cross sections are also not uniform as the colon can completely collapse at certain places, making the lumen difficult to see. The aim has been to make use of machine vision for guiding the terminal portion of the endoscope and spare the endoscopist from this task while the endoscope is advanced[1-3].

The current generation of endoscopes has a single fixed camera and there is no provision for the direct measurement of depth from UGI, colon or bronchus images. It is difficult to define an accurate reflectance function for the inner body surfaces, which are illuminated by a point light source accommodated at the endoscope tip. The light source and camera are assumed at the same point as they are located in the same plane and very close to each other on the endoscope tip as shown in Figure given below. Under these illumination conditions, the deepest area in the colon with respect to the viewer roughly corresponds to the darkest area in the image. Tip direction can be controlled accordingly during the endoscope insertion process. Region extraction is the most appropriate method for detecting dark regions in colon images where they are directly visible.

2. SIGNAL LEVEL PROCESSING

The endoscope navigation and advisory system can be viewed as a two-layer system. The first layer is at the signal level, which consists of the processing that will be performed on a series of images to extract all the identifiable features. The information is purely dependent on what can be extracted from the 'raw' images. At the signal level, the first task is performed by identifying a single dominant feature, lumen. Few methods of identifying the lumen are developed during our course of investigations.

2.1. Contour Extraction

The inner walls of a human UGI or colon contain circular rings of muscle as evident from the colon images shown in Figure 1. These rings are clearly distinguishable as they form occluding edges. When an endoscope is directed along the centerline of a straight section of colon, the muscle rings appear as closed contours in the image. The center of closed contours coincides with the correct insertion direction. For partially visible contours, an estimate of the insertion direction is made from their curvature[2].

The contours are extracted by edge detection, thresholding and linking. This method required images to be divided into overlapping squares (8 by 8 or 4 by 4) where line segments are extracted by using a modified Hough transform. Perceptual criteria, such as proximity, connectivity, similarity in orientation, contrast and edge pixel intensity, are used to group edges both strong and weak. This approach is called perceptual grouping.

2.2. Dark Region Detection

The second method is based on a region extraction using split and merge approach with spatial domain data. An N-level quadtree based pyramid structure is constructed to find the most homogenous large dark region, which in most cases corresponds to the lumen. The algorithm constructs the quadtree from the bottom (pixel) level upward, recursively and computes the mean and variance of image regions corresponding to quadtree nodes. On reaching the root, the largest uniform seed region, whose mean corresponds to a lumen is selected that is grown by merging with its neighboring regions[2].

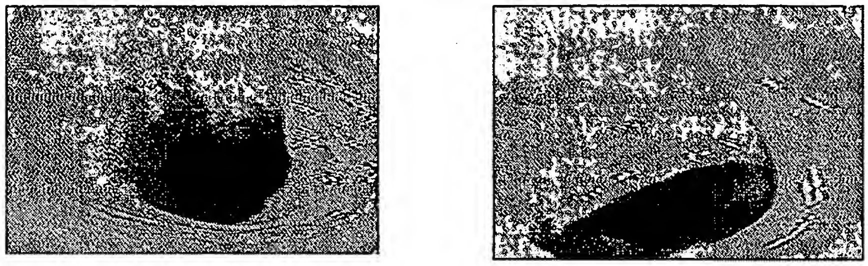

Figure 1 image of the inner wall of colon

2.3. Shape from Shading

In addition to the use of two-dimensional information in the form of regions and contours, three-dimensional shape can provide additional information that will enhance the system capabilities. Shape or depth information from an image is estimated by various methods. A particular technique suitable for endoscopy is the shape from shading, which is developed to obtain the relative depth of the colon surface in the image by assuming a point light source very close to the camera. If we assume the colon has a shape similar to a tube, then a reasonable approximation of the position of the center of the colon (lumen) will be a function of the direction in which the majority of the normal vectors of shape are pointing.

This approach is based on reconstruction of three-dimensional coordinates at each pixel point in an image by inverting the reflectance equation[4]. In the case of endoscope image formation, there is a useful illumination arrangement where the point light source and viewer are in the same plane and very close to each other. This has enabled researchers at the Imperial College[5] to devise a linear shape from shading algorithm to recover relative depth.

The shape from shading method reconstructs the surface normals $(p,q,-1)$ at a set of points in the image. The normals that we obtain from low-level processing consists of one vector (p,q) per pixel which gives the orientation of the surface at this point with respect to two orthogonal axes (x, y) that are perpendicular to the camera axis (z). The surface normal can vary from $p = q = 0$ when it is perpendicular to the endoscope's tip (camera), to p or q close to infinity when it is parallel to the camera. A reasonable approximation of the position of the centre of the colon (lumen) will be a function of the direction in which the majority of the (p,q) vectors are pointing to (except in the case in which the lumen is in the centre of the image, in which case there will be no dominant direction)[5]. Although it was necessary to assume that the colon has Lambertian surfaces, the results could be still be used to give a reasonable statistical estimate of the lumen position. In our system, a set of 32 x 32 pixel points is selected and the slope of surface at each point is computed. From these, the deepest point in the image is estimated.

2.4. Template Matching In Fourier Domain

Other techniques investigated includes the uses template matching to identify the lumen position[6] in Fourier domain. The template with the best correlation in magnitude gave an indication of the size and the phase of the first harmonic was used to indicate the position. Real time performance was achieved by computing two one-dimensional transforms on the horizontal and vertical projections of the image, rather than using the full two-dimensional transform, and by restricting the correlations to the low frequencies. The method proved effective in a large number of cases, and indeed would give a correct indication of position in the case where the lumen was not directly visible. However, it was unable to cope well with the artifacts such as diverticula or pockets on the inner walls, which also resemble the lumen.

3. CONTROL LEVEL PROCESSING

In the second layer, known as the control layer, for endoscope navigation, a decision model must be built for endoscope navigation and advisory system.

3.1. Probabilistic Networks from Objective Data

The system that we built is the models of probabilistic networks that create a basic, artificial intelligence system for navigation in the colon. We have constructed the probabilistic networks from correlated objective data using the maximum weighted spanning tree algorithm. Figure 2 shows the information involved in the reasoning about the location of lumen.

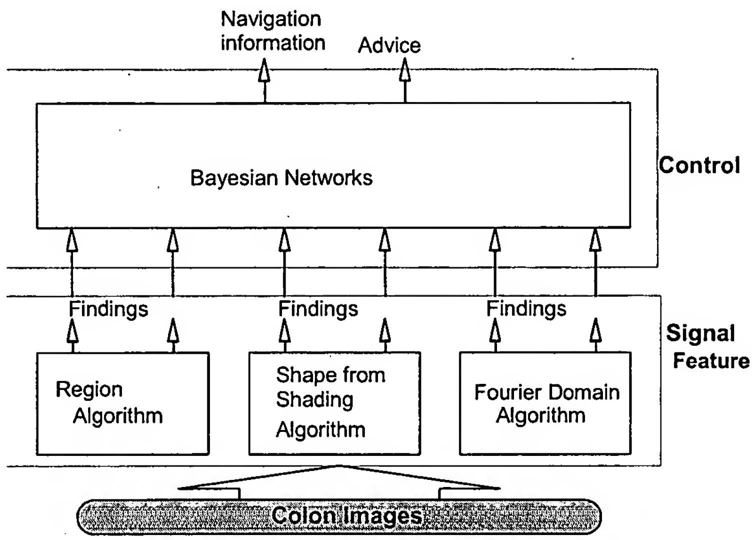

Figure 2 Continuous probabilistic network for estimation of the lumen location in the navigation module.

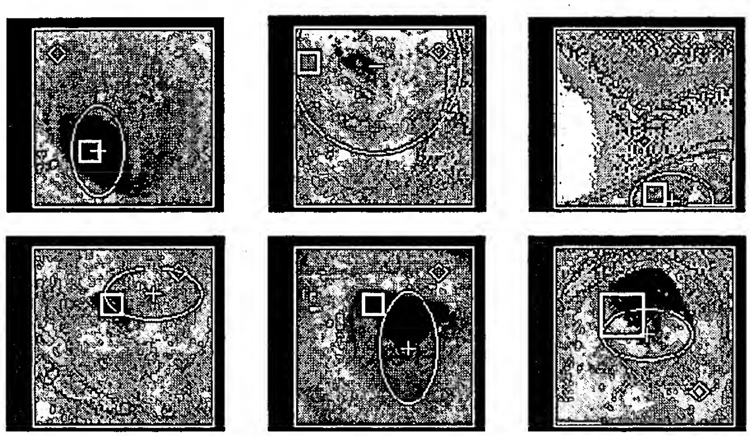

Figure 3 Some images with processed information

Figure 3 show some of the images where all the three models provide estimation of the lumen location. In these images, the cross is the estimated location of the lumen by the Fourier domain model with an ellipse indicating the estimated size of the lumen. The square is the large dark region estimated by the region based segmentation model and its centre will be the estimated location of lumen. Lastly the diamond in the images represent the estimated location of the lumen by the shape from shading algorithm.

In constructing a numerical expert system with many signal level models, we can approach the problem as a system that consists of many sub-systems, each with an associated probabilistic network. In the simplistic sense, they can be considered as branches in the total network[7]. In this simplest approach, we assume that all the interacting variables are observed and we want to construct a probabilistic network for each sub-system, using all the observed variables. The observed data, together with the topology, derived from a knowledge base, will be translated into prior and conditional probabilities for each state of

the variables. In order to determine the mapping from the problem to the solution space, the probabilistic network knowledge based system must be constructed from available data and information.

In the closed world definition, if **V** is the set of all interacting variables $\{V_1, V_2, V_3, \ldots\}$ for a model, then

$$P(\mathbf{V}) = \prod_{V_i \subset \mathbf{V}} P(V_i / pr(V_i)) \quad V_i, pr(V_i) \subseteq V \tag{1}$$

where $pr(V_i)$ is the parent of the variable V_i.

If we assume that the extracted features, denoted as variables **V**, are all that exist and are required to model a system, then we would expect to have observed data for all nodes in the desired network. Many researchers have developed algorithms for constructing the network topology from empirical observations[8-12]. Most of their algorithms are improvements of the maximum-weighted spanning tree algorithm first formulated by Chow and Liu[13] which utilised a mutual information measure to measure the divergence between the true (measured) distribution P and the tree-dependent distribution P_t as

$$I(P, P_t) = -\sum_{i=1}^{|X|} I(X_i, pr(X_i)) + \sum_{i=1}^{|X|} H(X_i) - H(\mathbf{X}) \tag{2}$$

In the above equation, $H(\ )$ is the entropy measurement of a (marginal) distribution. $I(\ )$ is the cross-entropy measurement between two distributions and $pr(\ )$ represents the casual parent. Since the last two terms of are constants, minimizing the divergence is equivalent to maximize the first term, the total branch weight. Hence, their algorithm is known as the maximum weighted spanning tree (MWST). These types of maximum connection weight algorithms have the big advantage of not needing to consider all the possible trees that could be constructed from purely objective data. However, the possible ignorance of some interacting variables will generate many probabilistic networks that could closely approximate the given observed data.

3.2. Naive Bayes Networks

In the earlier work, Sucar and Gillies[14] utilized both region based segmentation and shape from shading algorithms to implement an advisory module based on Pearl's[15] Bayesian networks and assumed total conditional independence for all the feature variables. The resulting basic artificial intelligence system performed better than a rule base system. Although the system performed well, there were still cases in which images were mis-classified.

3.2.1. First Generation Naive Bayes Advisory Module

One of the reason that the first generation advisory module mis-classified the colon images in certain cases was due to the conditional independence assumption of probabilistic networks had been violated. To overcome the problem, Sucar and Gillies[14] suggested the three strategies to handle correlated data: node deletion, node combination and node creation. In practice we seldom have 100% correlated data, and hence, node deletion will usually throw away some information. For node combination, we have a situation where two variables must be assigned to one object which is the generation of clique as in the paper of Lauritzen and Speigelhalter[16], but it increase the complexity of the problem dramatically. The third strategy, node creation appears to be a powerful solution method. Sucar proposed a methodological solution, namely consultation with experts, to derive a node that makes the two dependent variables conditional independent. However, it will, in general, be a very difficult process for the expert to define a function that will combine the information from the two evidence variables into a coherent variable. Hence, the next stage of the work is to devise a way to create a hidden node based on the statistical distribution of the two evidence variables and an objective function that satisfies the axioms of conditional independence in the framework of the probabilistic methodology. The approach uses the training data, without seeking expert opinion, to define a mapping that will fuse the dependent information.

Figure 4(a) illustrates the naming conventions of one of these models (sub-systems) and the 'naive Bayes' probabilistic networks. The fundamental conditional independence assumption for the above 'naive Bayes' models were found to be weak according to statistical testing.

3.2.2. Introduction of Intermediate Nodes

In order to improve the system performance, intermediate variables were into the probabilistic network as shown in Figure 4(b).

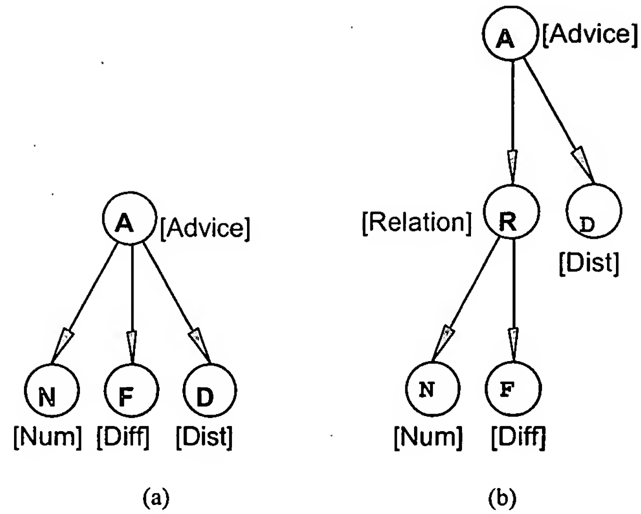

Figure 4 The Bayesian network for Dark Region model,
(a) the naïve bayes model and (b) model with additional node created.

To solicit the states of instantiation for the nodes [Relation] for each set of training data is a difficult task. Besides, even with these intermediate variables, an iterative iterative revision of the value of intermediate node is needed to ensure that the resulted network conforms closer to the conditional independence assumption than the original network. If the states for [Relation] are not well estimated, the performance of the new network can in fact be worsen. Hence, node creation is powerful but subjects the model to more uncertainty and usually requires much iteration to make the created node render its children conditional independent. This limitation motivated the development of a statistical regression method to collect training data and search for a mapping that will fuse the dependent information, without seeking expert opinion, statistically. This approach is the creation of hidden nodes (unobservable variables), to model the dependency[17].

3.3. Hidden Variables

In the construction of a probabilistic network, it is always assumed that the variables starting from the same parent are conditionally independent. However, this may not hold and will give rise to incorrect inferences. Pearl and Verma[18] stated that "Nature possesses stable causal mechanisms which, on a microscopic level are deterministic functional relationships between variables, some of which are unobservable." By adding hidden variables to model those nature hides from us, we should be able to satisfy the axioms of conditional probability and recover a better causal structure. A hidden node is transparent during data collection and its existence may be unknown to the expert. Its probability parameters are found by a search in the world of feasible values for the best value. For simplicity, we use the term unobservable variables to refer to these types of variables. From the derivation of the MWST algorithm, the divergence measurement can be used as a comparative performance measurement to select the best network structures. However, if there are some variables that are unobservable, then direct application of the divergence measurement is not possible.

In our work, we treated the problem of finding the best probabilistic network from different possible structures and different conditional probabilistic matrices, as an estimation problem. If we represent all the parameters in the probabilistic network as S, then the fundamental problem is the estimation of the parameters, S, given the known information, using only training data. Let X be the collection of training data and Y be all data in the environment ($X \subset Y$). If X can be separated into X_{in}, the measured values of input variables, and X_{out}, the desired value of output variables. The most common expression that is used to estimate the models parameters S, is

$$S(\mathbf{X}) = \max_{S} Q\left(\mathbf{X}_{out} \big/ S(\mathbf{X}_{in}) \right) \tag{3}$$

In our application, since there is no strict direction of signal flow, queries can be made at any node in the network. Hence we define the training data set X as collective of $\{X_1, X_2, X_3, ..., X_{|X|}\}$ and the above equation is modified to

$$S(\mathbf{X}) = \max_{S} \left\{ \forall_{i=1}^{|X|} \forall_{Z \subset \mathbf{X} \setminus X_i} Q\left(\mathbf{X}_i \big/ S(\mathbf{Z}) \right) \right\} \tag{4}$$

In this case we search for the parameters that will maximize the predictive ability of the model by allowing any node to be the query node and instantiating all other nodes as evidence nodes.

In Bayseian networks, the estimated posterior probability is denoted as $Bel(X_i)$ and the actual observed value of the query node denoted as $Q(X_i)$ can be used to quantify the ability of the model in estimating the true value of the query variable. If we define a monotonic error cost function for the differences between the desired posterior probability and the estimated posterior probability. The expected cost function will be a measure of the overall network's performance and can be used in a performance search algorithm to find the best estimation of S. There are many choice of cost functions for this application[19,20]. One such function is the sum of squared error cost function that has been widely understood by classical statisticians and widely used in many applications, it is also known as squared-error cost function.

Let the variable A be the decision variable and the training data $\mathbf{E} \in \Im$ (The full set of training data). If we are interested in the posterior probability of A given some evidence E, denoted as $Bel(A)$.

$$\xi = \sum_{i=1}^{|A|} \frac{1}{2} [Q(a_i) - Bel(a_i)]^2 \tag{5}$$

where $E\{.\}$ is the expectation operator, and $Q(a_i)$ is the observed value of a_i.

We then expand the expression for those conditional probabilities by a Taylor's series, so that we can use a gradient search method, such as least mean squares algorithm to find the solution. Updating is done using:

$$\begin{aligned} \underline{\underline{S(n+1)}} &= S(\underline{\underline{n}}) - \eta \Delta S(\underline{\underline{n}}) \\ &= S(\underline{\underline{n}}) - \eta E\left[\frac{\partial \xi}{\partial S(\underline{\underline{n}})} \right] \end{aligned} \tag{6}$$

In the creation of a hidden node, the conditional probability matrices linking the hidden node to its neighbors are determined using a gradient descent method which minimizing the objective cost function. The error gradients can be treated as updating messages and can be propagated in any direction throughout any singly connected network to adjust the network parameters[17,21].

It is well known that the quality and search time of a solution depends a lot on the initial estimate. The commonly used random number approaches often get stuck in an inferior local minimum and require multiple restarts or the process of simulated annealing to try to move them nearer a global minimum. Since the probabilistic network is formally derived, we derived a method of estimating the initial values of hidden using linear average[22]. With good initial starting point, the search algorithm will arrive at a good minimum point in roughly one-third of the training time as compared to a random numbers starting condition. Furthermore, the (first) solution was a good approximation to the global minimum without restart.

3.4. Optimising the Learning Rate (Armijo's Rule)

In this paper, we will discuss one aspect of the iteration technique employed in our minimization problem. The primary difference between most algorithms rests in the rule by which successive directions of descent are selected. The secondary differences lie in the selection of step size (also known as learning rate). For a general non-linear function that cannot be minimized analytically, a quadratic approximation is used and it is desired that at each iteration, we move towards the approximated minimum as quickly as possible. A practical and popular criterion for determining the optimal step size (learning rate) is the Armijo's rule[23]. Let us define the function

$$\phi(\alpha)=f(\mathbf{x}_k+\alpha\mathbf{d}_k) \tag{7}$$

where $f(\,)$ is the cost function, α is the step size, $\mathbf{x}_k$ is the current value of parameters and $\mathbf{d}_k$ is the direction of search.

Armijo's rule is implemented by consideration of the function $\phi(0)+\varepsilon\phi(0)'\alpha$ for fixed ε, $0<\varepsilon<1$. A step size is considered not too large if the corresponding function value is

$$\phi(\alpha)\leq\phi(0)+\varepsilon\phi(0)'\alpha \tag{8}$$

and α is considered not too small if, for $\eta>1$

$$\phi(\alpha)>\phi(0)+\varepsilon\phi(0)'\eta\alpha \tag{9}$$

From the above equations we can derive

$$\begin{aligned}&\phi(0)-\phi(\alpha)\geq-\varepsilon\phi(0)'\alpha\\&\phi(0)'=\left.\frac{\partial\phi(\alpha)}{\partial\alpha}\right|_{\alpha=0+}=\nabla f(\mathbf{x}_k)^T\mathbf{d}_k\end{aligned} \tag{10}$$

If the direction of search is the negative gradient for minimization, we have

$$\phi(0)-\phi(\alpha)\geq\varepsilon\alpha\left[\nabla f(\mathbf{x}_k)^T\nabla f(\mathbf{x}_k)\right] \tag{11}$$

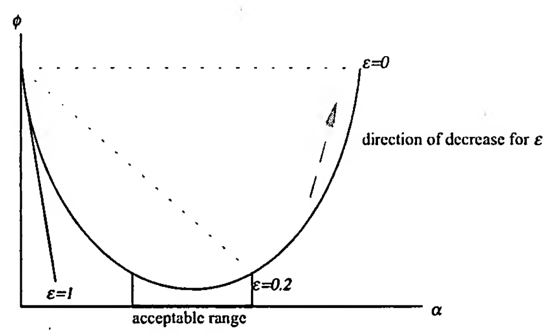

Figure 5 Pictorial illustration of ε in Armijo's rule

Figure 6 indicates that the improvement in performance must be greater than a fraction, ε, of the gradient projected in the search direction, which is the inner product expressed in the [ ].

In practice, our function f is the sum-of-squared error cost function, ξ, and our procedure to determine the optimal learning rate is as follows. We define

$$g(\alpha,\varepsilon)=\xi(S_k-\alpha\nabla\xi(S_k))-\xi(S_k)+\varepsilon\alpha\nabla\xi(S_k)^T\nabla\xi(S_k) \tag{12}$$

where $0<\varepsilon<0.5$

We tested the above rule for choosing the optimal step size. However, it is not easy to select the constant ε. From expert opinion, it is usually taken as constant of 0.2. However when we tested 0.2 for our system, the convergence speed was not satisfied. Hence modification to the choice of ε is critical especially we come close to the performance basin. One solution is to start with demanding constraint (high ε) and slowly relax the constraint (lowering ε) as we are reaching the minimum.

In this case, we treat the constant ε as a function of time, $\varepsilon(t)$. Another approach is to treat the constant ε as a function of the step size α, $\varepsilon(\alpha)$. In this case, we want the gain in performance to be significant (associated with large ε) if we were to allow a large step size and we allow the gain to be marginal (associated with small ε) if we only move with a very small step size α.

3.5. Experimental Results and Comments

Figure 7 provides the comparison of the various options illustrated by sub-graphs. In (a) we plot the sum-of-squared error for the root node. In (b) we plot the step size for each training iteration, and in (c) we plot the correlation performance between the estimated and actual observed data for the root node (solid line) and the two leaf nodes (dashed line and dotted line).

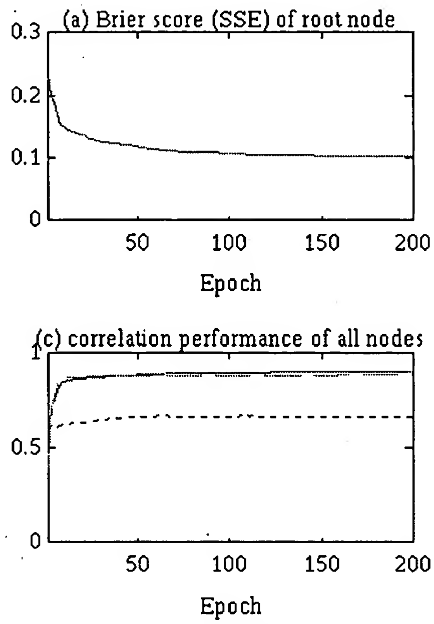

Figure 7 Adaptive Armijo's rule for optimal step size $\varepsilon = 0.5\ \alpha$

We did a comparison with the following test. (1) Using a fixed step size of 0.1 as is commonly found in literature of connectionist network. (2) Using an adaptive step size as commonly found in connectionist applications with increment ratio of 1.05 and decrement ratio of 0.7. (3) Using Armijo's rule for optimal step size with different ε constant as employed in operations research. (4) Using our adaptive Armijo's rule for optimal step size with different $\varepsilon(\alpha)$ function.

From the experiment (not shown) the constant step size approach is simple but will take a long time to reach the minimum. Furthermore, the solution will oscillate near the solution basin. In the case of adaptive step sizes, there are improvement but the learning time is still long and the ripple effect found near the minimum is reduced but still exists due to the heuristic rule by which the step size is adapted. When we tested the various constant ε values for the original Armijo's rule. Due to the nature of our solution space, we found that the original Armijo's rule brings the solution down very quickly (in 10 to 20 cycles) to near the optimal solution. However, due to the demanding requirement for subsequent improvement, the step size is always clamped to the minimum value. Hence it takes more than 2000 epochs to reach a minimum equivalent to the other method. The best ε constant for our application is 0.1. The above charts shown an adaptive Armijo's rule where $\varepsilon = 0.5\ \alpha$ provides the best solution. The algorithm brings the error monotonically down to the solution. The training time is reasonable, around 50 epochs to reach near minimum and around 150 to reach a good solution where subsequent cycles provide only minimum gain. In our system, the system performance is around 75% as compared to 64% with the naïve bayes structure.

4. CONCLUSION

In a typical engineering approach, we deal directly with sequence of endoscopic images. We have to understand the cues that a domain expert utilizes for decision making and translate those abstract cues into qualitative features, decide how and what features are to be extracted and construct a numerical knowledge based system for reasoning with evidence and uncertainty.

To prevent building an over complex probabilistic network incorporating all the features and getting trapped in the process of validating and modifying the interaction of many observed variables, we chose to model the system with two-level approach. At the signal level, we dealt directly with finding the feature sets and feature extraction models for influence. The system utilized multiple models to estimate the position of the lumen. These are the region segmentation model, the shape from shading model and a template matching in the Fourier domain.

In the control level, we used Bayesian networks as the numerical expert system for reasoning under uncertainty. Bayesian networks employs a graphical inference structure to capture explicit dependencies among the domain variables. In the advisory module where data collection is not a problem, the maximum weighted spanning tree algorithm (MWST) algorithm is commonly used to construct the inference structure. To improve the performance of our system, we proposed the creation of a hidden node to modify the constructed network topology, which in effect models the dependency of correlated variables, to solve the problem unobservable variables. The conditional probability matrices linking the hidden node to its neighbours are determined using a gradient descent method which minimizing the objective cost function. The error gradients can be treated as updating messages and can be propagated in any direction throughout any singly connected network to adjust the network parameters. Our method utilizes objective probabilities determined from the training data and constrained by the axioms of probability, and performance is maximized without expert intervention during training. Improvement in reducing search time was achieved by an adaptive Armijo's rule to determine the optimal learning rate for each iteration.

With the above two-level approach, we have built an automated endoscope navigation and advisory system successfully.

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Experiments with a Steady Hand Robot in Constrained Compliant Motion and Path Following

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Abstract

We consider the problem of cooperative manipulation to improve positioning and path following abilities of humans. Using a specially designed actuated manipulator and "steady hand" manipulation we report on compliant path following strategies and their experimental evaluation. Detecting lines and simple curve by processing images from an endoscope mounted on the robot, we traverse these curves autonomously, under direct user control, and in an augmented mode of user control. Anisotropic gains based on gradient information from the imaging reduce errors in path traversal.

1 Introduction

Several innovative surgical procedures such as treatment of occluded veins in the eye can be made possible through the use of "steady hand" manipulators by overcoming human sensorimotor limitations. An augmented procedure combines the precise positioning abilities of the robot and superior knowledge and experience of the surgeon that is difficult to encode in a machine for accurate administration of various treatments.

In addition to tool stabilization, the robot can remove tremor, performed scaled motions, enforce safety and retrace previous paths. To enforce safety, constraints can also be imposed to restrict the motion of the robot within a user-specified envelope around the detected path. The actions on meeting a constraint (stop, do not cross, ignore, inform user) can be programmed by the user. If the target location can be imaged and recognized using image processing, the robot can then "guide" the user towards the target by favoring motion in the desired direction.

This work reports experiments using a new "steady-hand" robot ([1]) developed at The Johns Hopkins University. This robotic system is designed to extend a human's ability to perform small-scale (sub-millimeter) manipulation tasks requiring human judgment, sensory integration and hand-eye coordination. The robot is operated using "steady hand" manipulation to provide damped tremor free microsurgery level motions. Immediate applications of this precise robot include eye surgery, microvascular surgery and neurosurgery.

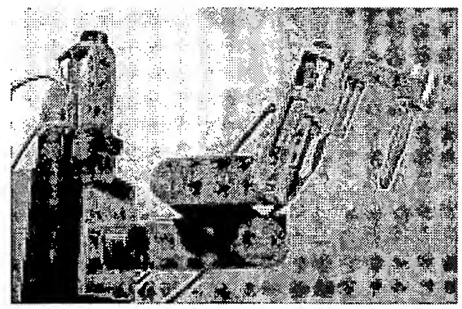

Figure 1: The Steady Hand robot

In the targeted application of treating occluded veins, the surgeon hand guides the robot to the treatment site. In addition, the vessels can be imaged using endoscopic images to add non-isotropic gains to favor motion along the desired path. We simulate this situation by using simple compliant motions with the new "steady hand" robot. In these experiments the robot traverses simple paths both under user control and autonomously. An endoscope is mounted on the robot to acquire real time images of the work area. The work area is illuminated appropriately to facilitate image acquisition. The paths to be traversed (lines and simple curves) are easily detectable in images acquired using the endoscope. The user "steady hand" guides the robot by looking at the output of the endoscope on a screen. The robot either a) "favors" compliant motion in the desired direction, b) just complies with the user-applied forces ignoring the detected path. Autonomously, the robot follows the path detected using the images.

Simple strategies are used to favor the desired direction of motion, such as anisotropic gains for compliance. The performance of the robot is judged using metrics such as mean, maximum deviation from the path. These experiments provide performance data for simple augmented procedures such as outlined above.

They are also indicative of benefits and user acceptance of "steady hand" manipulation

1.1 Previous Work

Task analysis and Cooperative Manipulation

Analysis of robot systems operating in tandem with humans and extraction of some information from this cooperation is an active topic of research. Control systems have been proposed by Kazerooni et al ([2-4]). Kosuge et al ([5-7];[8]) have looked at cooperative tasks in industrial environments. Several authors have proposed schemes suitable for cooperative tasks including impedance control strategies ([9], [10]), fuzzy and neural networks ([11]) etc. Generation of task sequences has been found to be an easier problem; especially for assembly environments and a large body of work are available on this ([12],[13],[14-16]). There is existing previous work in methods for determining force/position control parameters from a human worker's operation ([17, 18] ; [19, 20]). Some of these methods are specific to tasks and cannot be applied to other tasks.

In surgical robotics also cooperative control has been a current topic of research. Davies ([21]) and Troccaz ([22, 23]) among others have devised systems that incorporate some level of integration of task information for constrained control.

Evaluation of cooperative performance

Human performance in surgical procedures has also been studied ([24], [25]). Simulators have also been used to compare/assess surgical skill ([26]). Since complex surgical tasks are difficult to quantify automated performance comparisons in the past have used visual inspection by the experimenter (e.g. [24]) or an observer. Time of completion is often used as a major indicator ([27],[28],[29]).

Peg in hole tasks are commonly used to assess positional accuracy (e.g. [30]). Authors have also previously looked at comparative performance issues ([31]).

Most performance studies report the promise of performance improvement by using a robot over even skilled surgeons, at a cost of increased time of performing the task. They also report ease of use, some requirement for training and increased safety in using the robot.

Manipulator Systems

Manipulators have been applied to automation of assembly tasks for a longer period and consequently the need for development of efficient user interaction also became evident. More recently, sophisticated systems have been developed to assist, augment human actions in more complex environments, especially in medicine. Currently, they are used to reduce humans involved in a task (i.e. to act as tool, camera holders, or perform a similar routine task) more often than to actually use their superior manipulation abilities. This is similar to the industrial environment where also most of the initial automation consisted of teleoperated devices handling simple tasks or reproduced explicitly taught motions repeatedly.

As in the industrial domain, it has been realized that precision, efficiency, consistency of human performance limits the current practice in several fields of medicine. This is very evident in fields that require high dexterity, long durations of surgery, or high precision of motion.

There have been two approaches to adding automation to medicine. The first, more traditional approach has been to use telemanipulators (e.g. [32], [33], [34]). As in their industrial counterparts, these manipulator systems consist of a master and a slave system. The master robot faithfully reproduces the actions of the slave, often scaled to suit the application. Due to the complex nature of manipulation and difficulty in modeling the environment they perform few automated or "intelligent" functions. The advantages of this approach include a better, more comfortable operating field for the surgeon, scaling of sensory information, and motion commands.

Examples of telemanipulator systems for surgery include the JPL Robot Assisted Microsurgery (RAMS) ([32]) master and slave system, a very sophisticated system for microsurgery and the eye surgery system developed by Hunter et al ([33]) which consists of a master-slave robot system with bi-directional force and motion feedback.

The second, steady hand approach is a hands-on approach. The robot is equipped with a force sensor to sense user interaction. It still acts a slave to user motions but since the user is manipulating the robot as he would the tool, there is no scaling of motion. However, the sensory input driving the motion can be scaled appropriately. The advocates of this approach cite the simplicity, closeness to conventional procedures and therefore ease of use, reduced cost (due to a single manipulator), and improved kinesthetic among the advantages. Several such systems have been built as well.

The new "steady hand" robot ([1]; description below) is a sophisticated hand held manipulator system. The systems developed by Davies ([21]) and Troccaz ([22, 23]) also fall in this category. The LARS ([35]) is a

camera holding robot designed for laparascopy. Although it was envisioned to be operated with a joystick (and so is not truly a hand held manipulator), LARS has a force sensor built into its end effector that allows hand held manipulator functions.

In both approaches the operator has direct control of the manipulator and its motion. The second approach is more appealing because of its advantages, and also since an experimental platform for this is currently available. This approach will be used for this work.

2 Methods and Materials

2.1 Experimental Setup

The experimental environment includes the new "steady hand" robot. This is a 7-degree-of-freedom manipulator with XYZ translation at the base for coarse positioning, two rotational degrees of freedom at the shoulder (the RCM linkage, [36]), and instrument insertion and rotation stages. The instrument stages were not used for this experiment. A force sensor is built in the end-effector. This robot has a remote center of motion and an overall positional accuracy of 10s of microns.

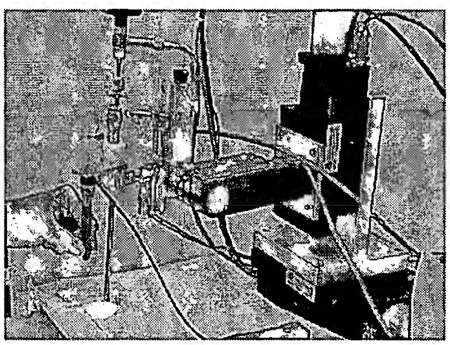

Figure 2: The Experiment Setup

The force sensor is mounted axially with the tool handle that is used for manipulating the tool. The sensor is a small commercially available force sensor (ATI Industrial Automation, NC). The endoscope is mounted on the rotation stage. The force sensor is mounted with its z-axis parallel to the instrument insertion stage of the robot.

The robot hardware control runs on a Pentium-II 450MHz PC with Windows NT operating system. An 8-axis DSP series controller card (PCX/DSP, Motion Engineering Inc, CA) is used to control the robot. The card provides servo control using DSP processor. The PC also houses the ISA force sensor controller. A Matrox Meteor II video capture card is used to digitize the video signal from the endoscope, which is then used for image processing to compute the location of the desired feature in the image.

A library of C++ classes has been developed for control purposes. This modular robot control (MRC) library provides Cartesian level control. It includes classes for kinematics, joint level control, command and command table management, sensor and peripheral support, and network support. Some exception and error handling is also built in. An array of sensors including serial and parallel ports, ATI force sensors, joysticks, digital buttons and foot pedals are supported.

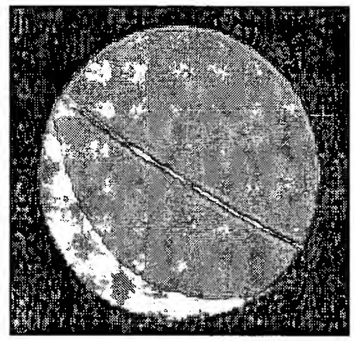

Figure 3: A picture captured from the scope camera, the curve on the left bottom is a part of the endoscope

A simple force proportional velocity controller has been implemented based on the MRC library. User forces at the tool are sensed using the force sensor, biased and resolved the coordinate frame of the robot for force-proportional velocity control. Both user forces and robot velocity are limited for safety. The base joints and the upper joints can be controlled independently by using a foot pedal. Control rates of over 1000Hz can be achieved using this controller.

2.2 Experimental Protocol

The line and curves drawn on paper are positioned in the working area of the robot and fixed. The robot is then initialized and image processing started. Robot is registered to the camera by detecting a circle on the paper in images taken from several robot positions.

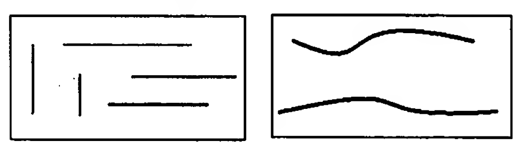

Figure 4: Straight lines (top left)., and simple curves (top right) used in the experiment.

During path traversal, each acquired image is thresholded, and a search is performed in the center of the image to obtain the gradient and center of the curve in the image. This gradient information is used to compute force gains for the control process in augmented mode. The proportional velocity control described earlier is then used for force proportional velocity control (figure 5).

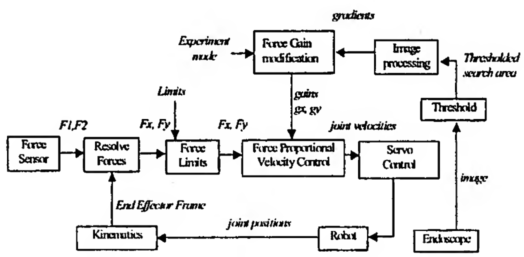

Figure 5: Experimental model

Following three experiments are performed.

a) *Autonomous*: the robot detects the curve in the images and moves to maintain the curve at the center of the image.
b) *Assisted*: the robot moves in response to user forces applied at the handle but does not take into account the information obtained from the image processing
c) *Augmented*: the robot moves in response to user forces but updates the anisotropic gains for control using the information obtained from the endoscope images

For each experiment the trajectory traversed, the location of the curve with respect to the center of image, the time taken, and forces applied are recorded. Two different set of joints, the translation joints in the base, and the rotation joints in the shoulder are used separately for the experiment.

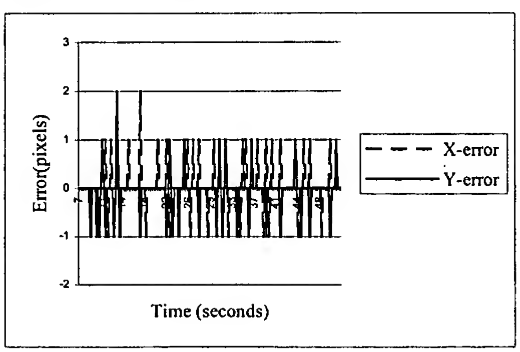

Figure 6: An error profile for automatic tracking for base translation joints (1 pixel = ~0.1mm).

3 Results

The users are able to trace the straight lines and curves easily in both modes. Augmentation appears to reduce errors. Due to image processing errors, if the gradient detected is not correct, it results in larger errors for the augmented version. Automatic tracking performs superior to other modes in most experiments.

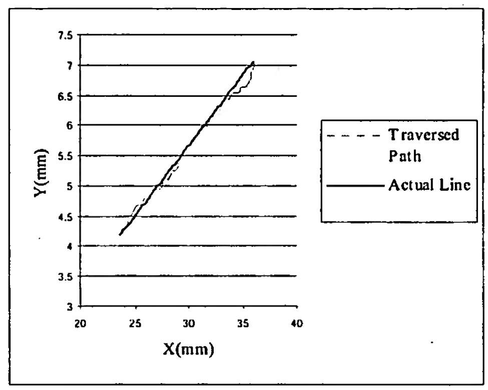

Figure 7: Traced path and actual line for visually guided (augmented) motion for base joints.

Straight lines are the first group of features selected. They simulate vessels to some extent. They are also easy to detect and process in the experimental setup. The robot consistently tracks (e.g. figure 6) to within 1 pixel (~0.1mm) average error. Without directional assistance from image processing the assisted experiment errors of up to 1 mm (figure 8) were commonly observed. The augmented version (figure 7) adds gradient information and reduces the average errors. Detailed results appear in table 1.

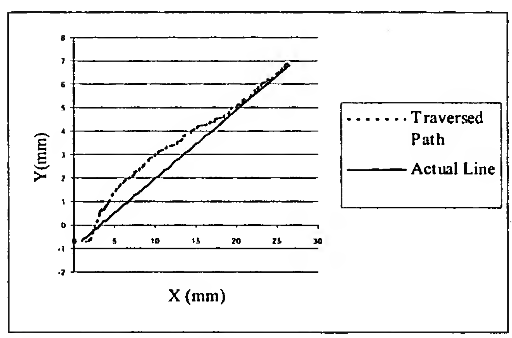

Figure 8: Traced path and actual line for simple compliant motion (assisted series) for base joints.

For simple curves, the gradient information obtained changes often. For automatic tracking, with slow speeds, it is possible to update the gradient information (obtained at about 5Hz) to keep up with the control

loop (at 1000Hz). The robot autonomously tracks to within an average of ~. 5mm from the center of image. It is more difficult to for users to traverse these curves using simple compliant motion and larger errors, up to 3mm are noticed. Using the gradient information in augmented versions reduces the error. Typical Mean and average errors appear in table 2.

The relatively slow rate of image acquisition (5Hz), and larger speeds due to user forces might account for the difference between automatic and augmented versions.

Experiment	Translation		Rotation	
	Maximum Error(mm)	Average Error(mm)	Maximum Error(deg)	Average Error(deg)
Automatic	0.22	0.03	0.47	0.26
Assisted	1.6	1.1	1.04	0.61
Augmented	1.75	0.95	1.12	0.37

Table 1: Typical Mean and Maximum Errors for lines

4 Conclusions And Scope

Current experience shows that "steady hand" approach hold promise for improving human performance. With its superior accuracy the robot can help in positioning tasks, very easily. Although image processing in real environments is much harder and information obtained has much more noise. It may still be possible to obtain enough information to assist the user to some extent.

Experiment	Translation		Rotation	
	Maximum Error(mm)	Average Error(mm)	Maximum Error(deg)	Average Error(deg)
Automatic	1.26	0.34	1.54	0.54
Assisted	2.99	2.32	1.9	0.66
Augmented	1.3	0.6	1.84	0.59

Table 2: Typical Mean and Maximum Errors for curves

Current robotic systems are slower compared to unaided humans (also noticed in [30], [31]) but enhance the performance in these simple tasks. Time is an important consideration in most surgical interventions and robotic systems need further improvement. As also reported by earlier studies ([31]) as well, the augmented "hand held" approach is easy to use and little user training is required to use the system.

Acknowledgements

We gratefully acknowledge the support of the National Science Foundation under grant #IIS9801684, the Engineering Research Center grant #EEC9731478. We thank Aaron Barnes for his help during this work. We also thank Dr. Louis Whitcomb for his helpful suggestions and Andy Bzostek for his valuable help in debugging.

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...using image **processing**, the robot can then "**guide**" the user...This robotic **system** is designed...position control **parameters** from a human...of these **methods** are specific...have devised **systems** that incorporate...surgical **procedures** has also...the tool **handle** that is used for **manipulating** the tool...NC). The **endoscope** is mounted...operating **system**. An 8-axis...using DSP **processor**. The PC also...

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Computer Methods and Programs in Biomedicine
Volume 69, Issue 3 , November 2002, Pages 211-224

doi:10.1016/S0169-2607(01)00192-4 Cite or link using doi

Design and implementation of a PC-based image-guided surgical system

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Received 1 November 2000; revised 15 August 2001; accepted 15 August 2001. Available online 25 August 2002.

Abstract

In interactive, image-guided surgery, current physical space position in the operating room is displayed on various sets of medical images used for surgical navigation. We have developed a PC-based surgical guidance system (ORION) which synchronously displays surgical position on up to four image sets and updates them in real time. There are three essential components which must be developed for this system: (1) accurately tracked instruments; (2) accurate registration techniques to map physical space to image space; and (3) methods to

display and update the image sets on a computer monitor. For each of these components, we have developed a set of dynamic link libraries in MS Visual C++ 6.0 supporting various hardware tools and software techniques. Surgical instruments are tracked in physical space using an active optical tracking system. Several of the different registration algorithms were developed with a library of robust math kernel functions, and the accuracy of all registration techniques was thoroughly investigated. Our display was developed using the Win32 API for windows management and tomographic visualization, a frame grabber for live video capture, and OpenGL for visualization of surface renderings. We have begun to use this current implementation of our system for several surgical procedures, including open and minimally invasive liver surgery.

Author Keywords: Image-guided surgery; Computer assisted surgery; Windows programming; Image display; Image registration

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Computer Methods and Programs in Biomedicine
Volume 69, Issue 3 , November 2002, Pages 211-224

Annu. Rev. Biomed. Eng. 1999. 01:211–240

ROBOTICS FOR SURGERY

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Key Words robot, manipulator, minimally invasive surgery, image-guided surgery, registration

■ **Abstract** Robotic technology is enhancing surgery through improved precision, stability, and dexterity. In image-guided procedures, robots use magnetic resonance and computed tomography image data to guide instruments to the treatment site. This requires new algorithms and user interfaces for planning procedures; it also requires sensors for registering the patient's anatomy with the preoperative image data. Minimally invasive procedures use remotely controlled robots that allow the surgeon to work inside the patient's body without making large incisions. Specialized mechanical designs and sensing technologies are needed to maximize dexterity under these access constraints. Robots have applications in many surgical specialties. In neurosurgery, image-guided robots can biopsy brain lesions with minimal damage to adjacent tissue. In orthopedic surgery, robots are routinely used to shape the femur to precisely fit prosthetic hip joint replacements. Robotic systems are also under development for closed-chest heart bypass, for microsurgical procedures in ophthalmology, and for surgical training and simulation. Although results from initial clinical experience is positive, issues of clinician acceptance, high capital costs, performance validation, and safety remain to be addressed.

CONTENTS

INTRODUCTION

Over the past decade, robots have been appearing in the operating room. Robotic technology is now regularly used to aim endoscopes in minimally invasive surgery and to guide instruments to tumors in brain surgery. The use of a robot to shape bones in hip replacement surgery was one of the groundbreaking applications (2, 3, 36). Based on three-dimensional (3-D) computed tomography images, the surgeon plans the location of the prosthetic replacement joint within the femur. In surgery, the robot moves a high-speed cutting tool to form the precise shape specified in the presurgical plan. The result is a far better fit between the bone and replacement joint than has been possible with conventional hand-held cutting instruments.

One reason surgical applications are progressing quickly is the large technology base that has been developed in robotics research in the past three decades (11, 37). Results in mechanical design, kinematics, control algorithms, and programming that were developed for industrial robots are directly applicable to many surgical applications. Robotics researchers have also worked to enhance robotic capabilities through adaptability (the use of sensory information to respond to changing conditions) and autonomy (the ability to carry out tasks without human supervision). The resulting sensing and interpretation techniques that are proving useful in surgery include methods for image processing, spatial reasoning and planning, and real-time sensing and control.

To understand the advantages of using robots in surgery, it is helpful to consider the differences in human and machine characteristics (summarized in Table 1); many promising applications are based on unique robotic capabilities. One key difference is precision and accuracy, or more generally, the ability to use copious, detailed, quantitative information. The combination of 3-D imaging data, computers, and intrasurgical sensors, for example, allows robots to accurately guide instruments to pathological structures deep within the body. Another important difference is that specialized manipulator designs allow robots to work through incisions that are much smaller than would be required for human hands or to work at small scales, where hand tremor poses fundamental limitations.

Humans are superior, however, at integrating diverse sources of information, using qualitative information, and exercising judgment. Humans have unexcelled dexterity and hand-eye coordination, as well as a finely developed sense of touch. Unlike interaction with robots, interaction with human members of a surgical team for instruction and explanation is straightforward. These differences in capabilities mean that current robots are restricted to simple procedures, and humans must provide detailed commands, using preoperative planning systems or by providing explicit move-by-move instructions. Even in the most sophisticated systems, robots are specialized to specific tasks within procedures; humans must prepare the patient, make many of the incisions and sutures, and perform many other functions. Robotic systems are best described as "extending human capabilities" rather than "replacing human surgeons."

Humans	Robots
Strengths	Strengths
Strong hand-eye coordination	Good geometric accuracy
Dexterous (at human scale)	Stable and untiring
Flexible and adaptable	Can be designed for a wide range of scales
Can integrate extensive and diverse information	May be sterilized
Able to use qualitative information	Resistant to radiation and infection
Good judgment	Can use diverse sensors (chemical, force, acoustic, etc.) in control
Easy to instruct and debrief	
Limitations	Limitations
Limited dexterity outside natural scale	Poor judgment
Prone to tremor and fatigue	Limited dexterity and hand-eye coordination
Limited geometric accuracy	Limited to relatively simple procedures
Limited ability to use quantitative information	Expensive
Large operating room space requirement	Technology in flux
Limited sterility	Difficult to construct and debug
Susceptible to radiation and infection	

[a]Adapted from Taylor & Stulberg (75).

In this article, we review enhancements and extensions of surgical practice by robotic technology. The article is divided into two main parts. In the first part, we characterize the main technical approaches under development for robotic surgery. In the second part, we describe specific surgical procedures where robots are used, including orthopedic, general, thoracic, and neurosurgery. We conclude with a discussion of current research issues and promising areas for future research.

ROBOTIC TECHNIQUES FOR SURGERY

Several trends in surgery are contributing to the growing acceptance of robots. Primary factors include the increasing emphasis on minimally invasive surgical techniques and the widespread availability of 3-D image data. Other robotic characteristics, particularly stability and the ability to work at small scales, provide the incentive for additional robotic applications.

Minimally Invasive Procedures

Over the past decade, several surgical specialties have been rapidly transformed by minimally invasive surgery (also called minimal access surgery) (12). A central example is laparoscopic cholecystectomy, or gallbladder excision, a common procedure that is executed almost exclusively using minimally invasive surgery techniques. Surgeons work through a set of three to five incisions approximately 1 cm in size. Long-handled instruments are used to grip and cut tissue within the body, and a video laparoscope provides a view of the internal operating field. Because this procedure avoids the long incision through the abdominal wall used in the conventional open procedure, patients recover more quickly. Benefits include greatly reduced discomfort, improved cosmesis, reduced convalescence and hospitalization costs, and less time away from productive work. Minimally invasive approaches have produced the same benefits in a number of other procedures, such as arthroscopic knee reconstruction and thoracoscopic lung resection.

The necessity of working through a few fixed incisions places severe limitations on dexterity in manipulation, and only a few procedures are possible with the current hand-held instruments. Lateral movement of the instrument shaft is not possible at the incision, which thus acts as a fulcrum, reversing the directions of the surgeon's hand motions at the instrument tip and varying the mechanical advantage as the instruments move in and out. The video monitor is often located on the far side of the patient, and the difference in orientation between the endoscope and the monitor requires the surgeon to perform a difficult mental transformation between visual and motor coordinate frames (76). Contact force perception is impaired by friction and varying mechanical advantage at the incision, and distributed tactile information is absent (34).

Robotic manipulators promise to solve many of these problems. The challenge is to design devices with good dexterity and intuitive control that can be inserted through small incisions. One focus is the development of general purpose systems that can execute a range of procedures in general, thoracic, and gynecological surgery (9, 31, 47). These systems are often configured so that the surgeon sits at a console in the operating room and uses a master control manipulator that sends commands to the robots performing the surgical procedure (Figures 1 and 2). Video images, and sometimes force sensations, are reproduced at the surgeon's console. Other systems under development are aimed at specific access modalities, such as percutaneous needle puncture and transurethral prostate resection. There are also systems that take advantage of robotic ability to perform stable and untiring holding tasks, such as endoscope pointing and organ retraction, and to work at microscopic scales.

Image-Based Procedures

Another catalyst for robotic surgery applications has been the development of noninvasive imaging techniques, including 3-D modalities such as computed tomography (CT) and magnetic resonance imaging, and 2-D techniques such as

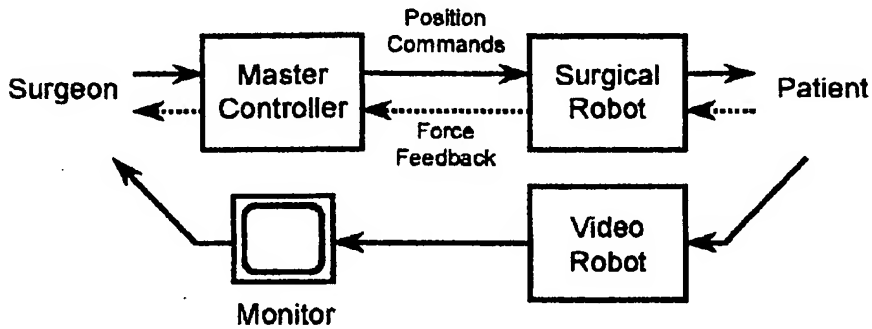

FIGURE 1 Information flow in robotic systems for minimally invasive surgery. The surgeon moves the master manipulators; these motions are sent as position commands to the robotic instruments that manipulate tissues within the patient's body. The surgeon views the internal operative field through video images from an endoscope, which is manipulated by another robotic system. Some systems also furnish audio, force, or tactile information.

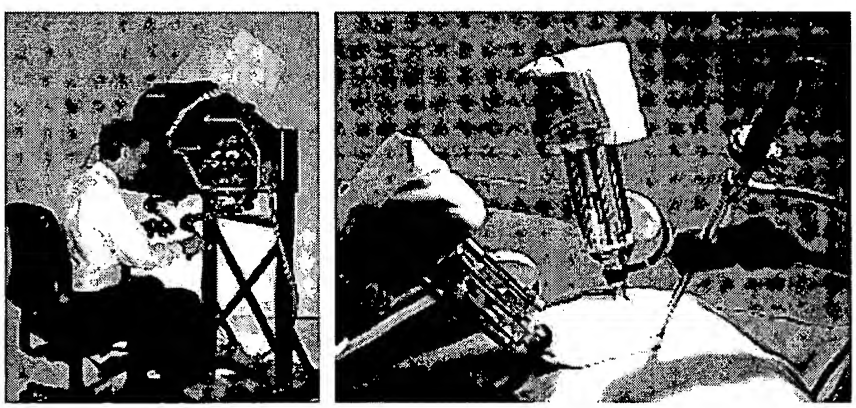

FIGURE 2 Minimally invasive telesurgery robots. Left: surgeon's control console. The surgeon grasps the master manipulator linkages, which also provide force feedback to allow the surgeon to feel the forces that the remote robot is applying at the surgical site. Video monitors (located above the workspace) are viewed in a mirror so that images of the instruments are registered with the master manipulator. Right: minimally invasive surgical robot system. Instruments are shown inserted through small incisions. Left and center modules are manipulators, right module is an endoscope. (From Hill JW, Jensen JF. 1998. Telepresence technology in medicine: principles and applications. *Proc. IEEE* 86(3): 569–580. Reprinted with permission.)

ultrasonography, fluoroscopy, and conventional X-ray radiography. Because these images can reveal the precise location of pathologies, new computational and mechanical tools can guide treatments to the pathology while sparing the surrounding healthy tissue. A typical example is biopsy and resection (removal) of brain tumors (28, 46). Preoperative magnetic resonance imaging can locate the tumor precisely within the skull. After opening the skull, a robot or human surgeon can guide instruments directly to the tumor, based on the image data. Collateral damage to brain tissue is minimized, and because brain structures can be distinguished in preoperative images, the instrument path can be planned to avoid critical regions. Procedures of this type require the solution of three central problems: planning, registration, and navigation, all of which are detailed in the sections that follow.

Planning For planning, the preoperative images must be processed to reveal the essential structures and then presented to the clinician in a suitable form. In some systems, path-planning algorithms operate on the image data, and the results are presented to the surgeon for validation (e.g. 36, 80). The planning process often begins with segmentation of the image data into physiologically meaningful regions. In current procedures, the clinician may perform this operation mentally, but there is considerable interest in automated segmentation. Many approaches are under development, including statistical categorization, matching between anatomical atlas and image data, and physiological approaches such as modeling growth patterns to determine organ shape (5, 49, 81). In the brain tumor example, segmentation requires identification of the location and boundary of the tumor and separation of the various component structures of the brain. Precise segmentation is essential to avoid removing healthy tissue or leaving residual malignancy. Figure 3 (see color figure) shows the output from an image-guided neurosurgery planning and navigation system (28).

The processed image data is then presented to the surgeon for analysis of the patient-specific anatomy and specification of the treatment plan. For brain tumors, this user interface must provide a method for interactively displaying 3-D imaging data on a 2-D computer screen; it must also provide a method to specify the incision point and instrument path. For some procedures, such as hip replacement surgery (see below), computational algorithms automatically calculate an optimal treatment plan, which is presented to the clinician for verification (e.g. 19, 36, 80). Planning methods must take into account the specifics of the organs involved as well as the treatment methodology, so many different approaches to the computational and user interface aspects have been developed. A sampling of these systems is presented below.

Registration To implement this preoperative plan in the operating room requires registration of the image data with the patient's anatomy (44, 69). Registration finds the correspondence between points in the preoperative image data and points on the patient's anatomy on the operating table. Two general approaches have been developed: fiducial-based and shape-based schemes. In the former approach,

fiducials, or markers, are attached to the pertinent anatomical structure prior to imaging. From the image data, the robot control computer knows the location of the pathology with respect to the fiducials. During surgery, the markers are exposed and a sensor system conveys their location to the computer. Many sensing systems can be used for determining fiducial location. The most direct is a probe attached to the robot manipulator itself, so that when the robot contacts a fiducial, its location in the robot's coordinate space is immediately determined. From contact with several fiducials, the complete spatial transformation between the preoperative image and the patient can be found.

A number of sensing systems are used in surgery (51, 70). One of the most common is the optical tracker. Light-emitting diodes or reflective targets are attached to a probe, and a set of cameras or optical sensors view the probe from known locations. Triangulation can then determine the location of each target in the robot coordinate frame; submillimeter resolutions are readily achieved. Other sensing techniques include electromagnetic transceivers, articulated probe arms, and ultrasonic and laser range finders. Many of these tracking modalities are available as an integrated part of commercial image-guided treatment systems.

One problem with fiducial-based registration is that the attachment of the markers, which must be carried out prior to imaging, can be a significant surgical procedure in itself. For example, the ROBODOC system for hip replacement surgery uses fiducials that are pins implanted in the femur at both the proximal and the distal ends (see below). This adds time and cost to the robotic procedure and can cause significant discomfort for the patient.

The alternative approach, shape-based registration, avoids these problems by fitting the shape of anatomical structures from intraoperative measurements to the preoperative image data. The patient measurements can be obtained from a variety of sensing techniques, including tracing curves on the pertinent anatomical structure with an optical tracker probe, scanning the surface with a laser range finder, or processing video images of the patient. The result is a description of the shape of the anatomical structure in patient coordinates. A computational algorithm then finds the spatial transformation that minimizes the error between the intraoperatively sensed shape and the shape that has been segmented from the preoperative image data.

There are many other variants on the registration problem. One potentially advantageous approach uses readily obtained 2-D ultrasound or X-ray images as the intraoperative sensing technique. The resulting "slices" or projections of the anatomy are then fitted to the 3-D preoperative image data (20, 77). A significant problem in registration is correcting for motion of the patient or deformation of tissue during surgery. This is particularly important in neurosurgery, where swelling of the brain follows a craniotomy. Deformable template matching and biomechanical models that incorporate response to mechanical loading or the edema process have been proposed as a way to deal with this problem (41, 56a). Other tracking approaches use video images to follow patient motion in real time (27). Verification of the accuracy of registration techniques has also become an important research question (17, 25). Because it sets fundamental accuracy limits, reg-

istration is important for all areas of image-guided therapy and has attracted a great deal of research interest in recent years.

Navigation Following registration, the preoperative plan and image data can be used for navigation or guidance, by either a robot or a human surgeon. In the case of a robotic manipulator handling an instrument, the sensors in the robot's joints are used with the kinematic model of the manipulator to control the motion of the instrument in a fixed coordinate frame (11). Because the patient and the image data have been registered with this frame, the control computer can relate instrument motion to the patient's anatomy and the presurgical plan. For a human surgeon, guidance is provided for maneuvering hand-held instruments. Sensors track the motion of the instruments, and a computer displays motion instructions to enable the surgeon to navigate to the pathological tissue (28). The choice of robotic versus manual navigation is based on a number of factors, including cost, implementation difficulty, clinical acceptance, and safety concerns. In both approaches, the treatments are enabled by the use of computers and sensors to manipulate quantitative image data in ways that are impossible for humans alone. Further development of robotic technology can be expected to lower development and system costs, and to increase precision so that in the future more of the manual procedures may be executed robotically.

Interaction Modes

Surgeons can interact with robots in many ways. One fundamental categorization is in terms of the level of autonomy exercised by the robot. Currently, a few procedures are executed autonomously, i.e. the robot carries out a preoperative plan without immediate human intervention. Examples are found in hip joint replacement (36) and radiosurgery (66), where the complex or repetitive optimal paths that are calculated would be impossible for a human surgeon to follow with sufficient precision. In this situation, the surgeon plans and sets up the procedure, then monitors its execution to ensure compliance and safety.

Other procedures are performed interactively or assistively, meaning the surgeon and robot share control (79). One example is a robotic system for bone cutting in knee joint–replacement procedures (32). The surgeon grasps the cutting tool at the end of a low-impedance robot manipulator and moves the tool to reshape the bone to fit the prosthetic joint. The robot monitors the surgeon's actions and permits free motion in the appropriate cutting region but applies forces to prevent motion into regions where bone should not be removed. This allows the surgeon to supervise and control the robot, using innate human sensing and judgment, while it also provides ''active constraints'' that increase safety and accuracy of the cutting process. This approach may also improve acceptance of robotic systems by surgeons and patients, as the surgeon remains in control of the procedure. Robots for assistive control applications may require new manipulator designs; most robots are designed for high stiffness to ensure geometric

accuracy at the tip in the presence of variable task loads. This makes it difficult to design a sensing and control scheme that allows the robot to follow the surgeon's hand without the application of large forces or significant time delays.

At the other extreme of the autonomy scale, the minimally invasive surgical robot systems described in the previous section are often controlled explicitly by the surgeon. Each motion the surgeon makes with the master manipulator at the control console is transmitted to the robot working inside the patient's body (Figures 1 and 2). The surgeon formulates all motion commands on the basis of sensory information returned from the surgical site, which usually consists of video images. Because the master manipulator is physically separate from the surgical robot, this control mode falls under the category of teleoperation, even though the surgeon is usually located in the operating room with the surgical robot (67a).

Researchers have proposed that this technology will allow surgeons to treat patients from a considerable distance (31, 62). This could reduce the need to transport patients to highly specialized surgeons and avoid exposing surgical personnel to hazardous conditions in wartime or following natural disasters. A central problem is communication delays: Satellite links, for example, often have round-trip delays that last from a fraction of a second to several seconds. This can greatly slow task execution, as the surgeon must pace the procedure to wait to see effects of commanded motions. In the case of force feedback, it has been known for decades that delays of this magnitude can cause instability of the robot control system, although various techniques can help to minimize this problem (67a, 68). A less ambitious application is telementoring, where an experienced surgical specialist can observe and advise surgeons performing a procedure in a distant location. Robotics permits new forms of interaction in telementoring, such as giving the mentor control of the endoscopic camera (65). It remains to be seen whether the benefits of long-distance telerobotic surgical applications will outweigh the technical hurdles, acceptance barriers, and attendant costs (39).

Limitations of Robotic Surgery

There are, of course, many limitations to the application of robotics to surgery. Currently, the mechanical design of manipulators limits dexterity, particularly for minimally invasive procedures with severe size constraints. There is considerable room for improved kinematic configurations, as well as more compact and efficient actuator and transmission technologies. In terms of sensing and control, robots are controlled by computers and thus share many of their all-too-familiar shortcomings, especially for autonomous operation. Robots follow instructions literally, are unable to integrate diverse sources of information, and cannot use qualitative reasoning or exercise meaningful judgment. Although complex 3-D imaging information can be preprocessed to allow execution of very precise tasks, robots have a limited ability to use information from disparate sensors to control behavior during the course of a procedure. Increasing computational power may

improve robot control capabilities, but the resulting complexity makes it increasingly difficult to program and debug these systems.

SURGICAL APPLICATIONS

Robotic technology is finding its way into diverse surgical procedures, both revising the way current procedures are executed and enabling new procedures. We review the current state of research for the main surgical specialties that have been the focus of robot applications, emphasizing orthopedics, general and thoracic surgery, and neurosurgery.

Orthopedic Surgery

Orthopedics was one of the first areas of surgery in which robot applications were developed. Compared with soft tissues, bones are relatively easy to manipulate and deform little during cutting, so image-guided techniques are relatively straightforward to implement. The result is that robotic procedures can result in far better agreement with a preoperative plan than with the analogous manual procedure. Orthopedic applications that have received the greatest attention are hip and knee replacement and spinal fusion; additional work is under way in a variety of other areas, including craniofacial reconstruction and fracture treatment.

Total Hip Arthroplasty: Femur Preparation The replacement of hip joints that have failed as a result of disease or trauma has become commonplace. The procedure begins with disarticulation of the joint and removal of the proximal head of the femur. A metal and polymer prosthetic cup is then placed in the acetabulum. The femoral implant consists of a long metal shaft (up to 220 mm) that is inserted into a deep cavity that must be formed along the proximal axis of the femur (52). The prosthetic components are shown in Figure 4.

In the current manual procedure, the surgeon cuts the cavity by forcing handheld broaches and reamers into the femur, which leaves a rough and uneven surface. Until recently, the implant was cemented in place in this pocket, but long-term postoperative data indicated that the cement could crack, loosen, or cause osteolysis, leading to failure of the implant. Newer cementless implants have a porous metal surface and rely on natural bone growth into the metal for fixation. This ingrowth requires close proximity (0.25 mm or less) between the bone surface and the implant, so long-term success is highly dependent on a tight fit between the implant and the femur (52).

The need for improved precision led to the creation of a robotic approach to forming the femoral cavity. Development of the ROBODOC system began in the mid-1980s, and it is now commercially available in Europe and is undergoing FDA approval trials in the United States (36). The system provides two main advantages over the manual procedure. First, clinical trials have confirmed that

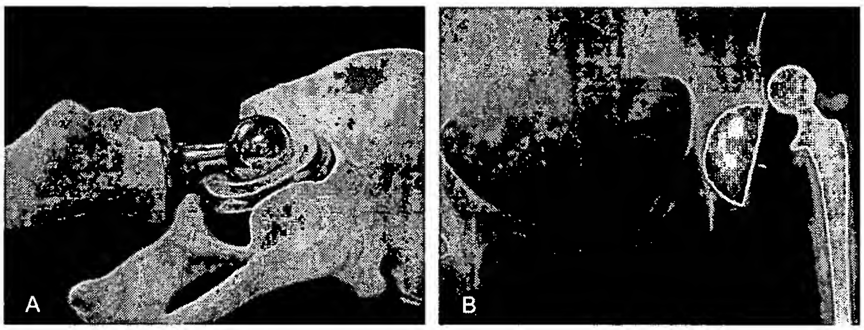

FIGURE 4 *A*. Prosthetic femoral implant (*above*) and acetabular cup (*below*) for total hip replacement surgery. *B*. X-ray showing dislocated prosthetic components in hip. (*A*. from Moody JE, DiGioia AM, Jaramaz B, Blackwell M, Golgan B, et al. 1998. Gauging clinical practice: surgical navigation for total hip replacement. In *Proc. Med. Image Computing and Comp.-Assisted Intervention, Cambridge, Mass*, ed. WM Wells, A Colchester, S Delp. Cambridge, MA, p. 421. Berlin: Springer-Verlag. Reprinted with permission. *B*. from Simon DA, Jaramaz B, Blackwell M, Morgan F, DiGioia AM, et al. 1997. Development and validation of a navigational guidance system for acetabular implant placement. In *Proc. Comp. Vis., Virtual Reality Robotics Med., Med. Robotics Comp.-Assisted Surg., 1st, Grenoble, France*, ed. J Troccaz, E Grimson, R Mosges, p. 583. Berlin: Springer-Verlag. Reprinted with permission.)

the femoral pocket is more accurately formed. Second, because of the need to provide precise numerical instructions to the robot, preoperative CT images are used to plan the bone-milling procedure. This gives the surgeon an opportunity to optimize the implant size and placement for each patient.

The robotic procedure begins with preoperative placement of three titanium pins in the femoral condyles and greater trochanter for registration purposes. Next, the patient undergoes a CT scan, which is loaded into presurgical planning software running on a personal computer. The system interactively displays various views of the image data, and the surgeon selects the appropriate implant from a library and then specifies its placement, considering factors such as leg kinematics and bone density.

In the operating room, the surgical team places the acetabular cup and removes the head of the femur, as in the manual procedure. The femur is rigidly clamped by a "fixator" that is attached to the base of the robot to ensure a fixed, known spatial location. The registration pins are exposed, and a probe on the tip of the robot arm is brought into contact with each pin, which completely specifies the transformation between the preoperative plan and the physical location of the femur. A safety check system confirms that the robot probe locations and the preoperative image show the same spatial relationship among the pins. A high-speed milling device at the end of the robot arm then cuts the femoral cavity. The control of ROBODOC is essentially autonomous: the robot follows the planned

cutting paths without the surgeon's guidance. After the pocket is milled, the surgeon continues as in the manual procedure.

The first human trial of the system took place in 1992. Recent reports on approximately 130 hip replacements from an ongoing clinical study in the United States used radiographs to compare ROBODOC-treated patients with a control group (2). The ROBODOC cases showed significantly less space between the prosthetic and the bone. Placement of the implant was also improved. Furthermore, no intraoperative femoral fractures occurred for the ROBODOC group, whereas three were observed in the control group. In Europe, the regulatory environment has permitted wider deployment of the system. Between November 1994 and February 1998, more than 1000 patients were successfully treated at 17 sites in Germany and Austria (3). The results also showed improved prosthetic fit, and the overall complication rate was reduced to 11.6% from the reported manual procedure rates of 16.6% to 33.7%. In addition, the surgical time decreased dramatically as surgeons gained experience with the system and modified the procedure: the first 10 cases averaged 220 min, whereas the current level is 90–100 min (4).

Although results of these studies show that the system successfully achieves the goal of improved fit, there are a number of difficulties that are common to many image-guided surgical procedures. One area for improvement is the traumatic pin placement procedure and slow pin-finding registration process. Work is under way to reduce the number of pins and then to eliminate them altogether, using other registration techniques (71). Another issue is the complex method for fixing the femur to the base of the robot, which is time consuming to set up and can cause postoperative pain in the knee. A related problem is motion of the bone within the fixator during cutting. Currently, a separate sensing system is required to check for motion; if bone shift is detected, cutting is interrupted and the registration process must be repeated. Several incidents of femur motion can push the surgical time over the limit of acceptability. An improved fixation technique or continuous registration method could eliminate these problems. Finally, although prosthetic fit and positioning appear to be improved, it is crucial to address the question of whether this improves treatment in the long term, as the current orthopedic literature does not show a significant correlation between implant fit and long-term outcome (2).

Total Hip Arthroplasty: Acetabular Cup Placement Hip dislocation occurs when the head of the femur disengages from the acetabular cup, as shown in Figure 4. Dislocation is one of the most common postoperative complications following total hip replacement surgery, with a rate of 1%–5% (53). The cause of dislocation is related to a number of factors, particularly malposition of the acetabular implant component. Incorrect positioning can allow the neck of the femoral implant component to impinge on the edge of the cup or a bony prominence on the pelvis, forcing out the femoral head. Unfortunately, current manual alignment devices configure the implant with respect to the gross body axes of

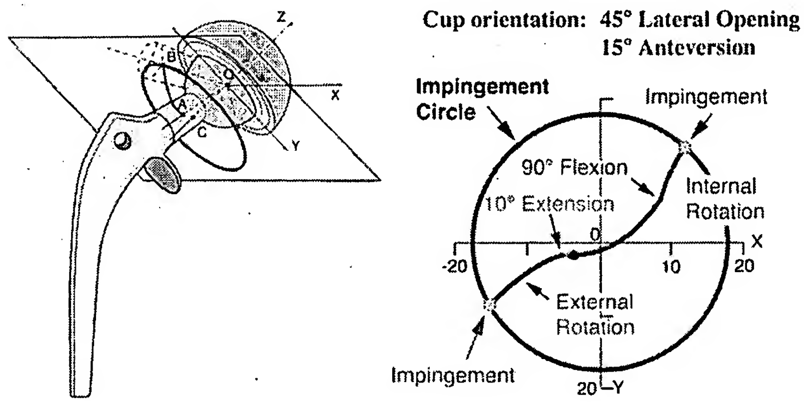

FIGURE 5 Range of motion (ROM) simulator for determining the orientation of the implants at which impingement between femoral neck and acetabular cup would occur. (From Moody JE, DiGioia AM, Jaramaz B, Blackwell M, Golgan B, et al. 1998. Gauging clinical practice: Surgical navigation for total hip replacement. In *Proc. Med. Image Computing and Comp.-Assisted Intervention, Cambridge, Mass,* ed. WM Wells, A Colchester, S Delp. p. 421. Berlin: Springer-Verlag. Reprinted with permission.)

the patient and do not take account of the pelvic orientation on the operating table and individual variations in pelvis geometry.

To reduce this complication, a system for accurate placement of the acetabular cup implant is being developed (53). The HipNav system consists of a preoperative planner, a range of motion simulator, and an intraoperative tracking and guidance system. The range of motion simulator helps surgeons to determine the orientation of the implants at which impingement would occur (Figure 5). Used in conjunction with the planning system and preoperative CT scans, the range of motion simulator permits surgeons to find the patient-specific optimal orientation of the acetabular cup. In surgery, a tracking system must register the location of the pelvis with the preoperative plan and monitor the location of the cup to guide the surgeon to properly place the implant.

Knee Surgery The knee is a complex joint, with large rolling surfaces and an elaborate system of ligaments precisely configured to constrain lateral motion. Navigational systems are under development for various knee-related procedures, such as anterior cruciate ligament replacement (45). Most robotic assistant systems for the knee, however, are aimed at total knee replacement (TKR) surgery. This procedure replaces all of the articulator surfaces by prosthetic components. In TKR, the surgeon uses a jig system to guide bone sawing. Jig placement is based on presurgical X-rays and limited visual information from the exposed bone surface. Because of the lack of intraoperative information, reports suggest that a

sizable fraction of current manual procedures result in clinically significant inaccuracies, and up to 40% of the patients are left with patellofemoral pain or limited flexion after conventional TKR surgery (1). The alignment of femur and tibia and the location of ligament attachments are crucial; small displacements (2.5 mm) of the femoral component have been shown to alter the range of motion by as much as 20° (22).

Several robotic TKR assistant systems have been developed to increase the accuracy of the prosthetic alignment. Many of these systems include an image-based preoperative planner and a robot to perform the bone cutting (19). Kienzle et al (38) have developed a system that uses the robot to guide jigs to the correct location, which then allows the surgeon to make accurate bone resections. First, the PUMA 560 robot tracks the motion and locates the center of the femoral head while the surgeon manually flexes and abducts the thigh. The robot uses this landmark as a fiducial in addition to the preoperatively implanted pins to guide the cutting tools to the position where the femur is to be resected. After the surgeon makes the cut for the femur, the robot guides the cutting location for the tibia using the implanted pins. To maintain registration, the pelvis and the ankle are fixed to the surgical table, and the distal femur and proximal tibia are locked with respect to the base of the robot using a six degree-of-freedom arm. This mechanical arm must be attached to the bones without interfering with the activities of the surgeon. Accurate calibration of the robot proved to be one of the largest obstacles for this project. Most industrial robots are built with high repeatability but insufficient positional accuracy. A specialized calibration technique has been implemented, and preliminary results indicate that an accuracy of less than 1 mm and 1° is plausible.

The TKR system developed by Davies and colleagues (16) is similar, but in place of manual sawing, the surgeon guides a cutting tool supported by the robot (Figure 6). The robot can provide a virtual jig by applying resistive force to the surgeon's hand. Areas such as nerves and ligaments are also excluded from the robot workspace. This system is intended to allow the surgeon to stay in control while minimizing human errors. Animal studies have shown that the overall accuracy is approximately 1.3 mm.

Spine Surgery Spinal fusion procedures attach mechanical support elements to the spine to prevent relative motion of adjacent vertebrae. Traditionally, the posterior spine is exposed, then pilot holes are prepared and screws are inserted into the vertebrae using the surgeon's anatomical knowledge and CT films. The screws must accurately reach a deep target without direct visual information. Small lateral and angular errors at the surface can lead to large errors at the screw tip, and the error cannot be monitored continuously during the procedure to avoid radiation overexposure. Compared with hip and knee surgery, these procedures present additional difficulties with registration, including movement of the vertebrae due to respiration and drilling.

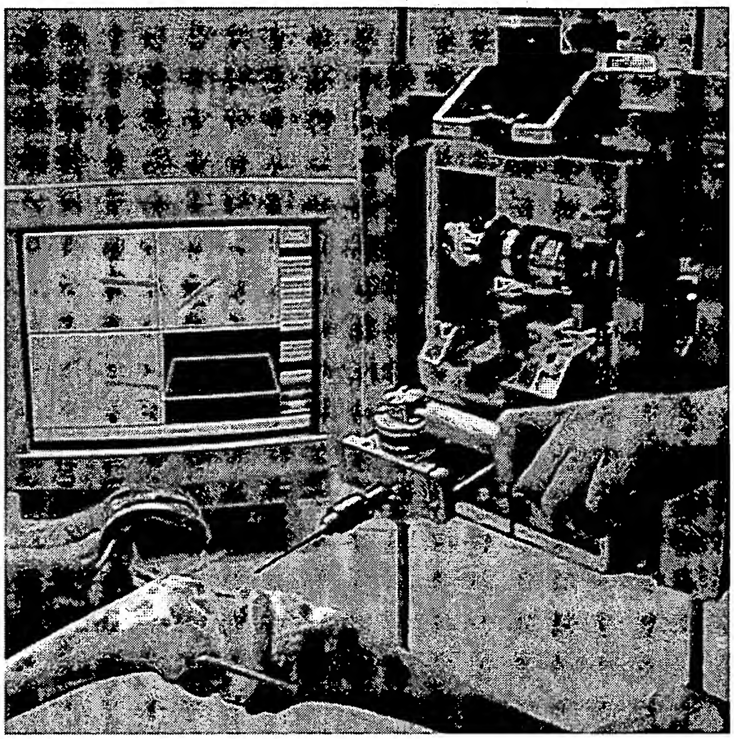

FIGURE 6 Total knee replacement robot. The surgeon guides the cutting tool while the robot generates constraint forces to ensure accuracy and protect key structures. (From Harris SJ, Jakopec M, Hibberd RD, Cobb J, Davies BL, 1998. Interactive pre-operative selection of cutting constraints, and interactive force controlled knee surgery by a surgical robot. In *Proc. Med. Image Computing and Comp.-Assisted Intervention, Cambridge, Mass,* ed. WM Wells, A Colchester, S Delp. pp. 996–1006. Berlin: Springer-Verlag. Reprinted with permission.)

Current research in spinal surgery focuses on image-guided passive assistance in aligning the hand-held surgical drill. Preoperative CT images are integrated with tracking devices during the procedure. Targets may be attached to each vertebra to permit constant optical motion tracking during the procedure. Using these techniques, Merloz et al (50) report a far lower rate of cortical penetration for computer-assisted techniques compared with the manual procedure. Work is under way on the use of intraoperative ultrasound or radiograph images to register the CT data with the patient (43). The screws may then be inserted percutaneously, eliminating the need for exposing the spine.

Neurosurgery

Neurosurgery was the first surgical specialty to use image-guided techniques, beginning with stereotactic frames that were attached to the patient's cranium before the imaging process and remained in place during surgery. The relationship between the frame and lesion observed in the image was used to guide the instruments within the brain. Newer image-guided techniques, sometimes called frameless stereotaxy, use less invasive fiducial markers or video images for registration and optical trackers for navigation of hand-held instruments (27, 28, 44). To enhance stability, accuracy, and ease of use, a number of robotic systems have been developed for these procedures over the past 15 years (e.g. 24a, 26, 40, 46, 48).

One issue in image-guided neurosurgery is shifting of the brain during the procedure, which alters the spatial relationship between the preoperative image data and the anatomy of the patient. Various solutions have been proposed to deal with this problem, including deformable templates for nonrigid registration, sometimes based on biomechanical models of soft tissue (41, 56a). Another solution is to perform the procedure inside an imaging system, which permits continuous monitoring of the anatomy and instrumentation. This requires robotic manipulators that are compatible with the imaging modality and space constraints (48).

Radiosurgery uses a beam of radiation as a surgical instrument to destroy brain tumors. If the angle of incidence of the beam is pivoted through a large range, the beam passes through the tumor at all times but intersects each point of adjacent tissues only briefly (Figure 7). Planning algorithms can optimize the path to gen-

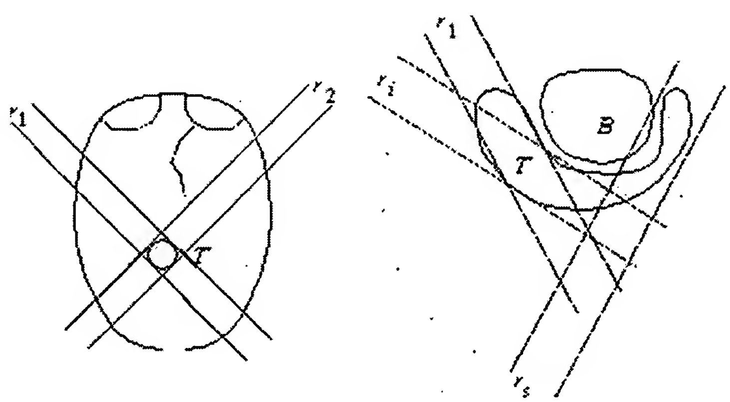

FIGURE 7 Radiation beam for radiosurgery passes through the tumor at all times but intersects each point of adjacent tissue only briefly. (From Schweikard A, Adler JR, Latombe J-C. 1993. Motion planning in stereotaxic radiosurgery. *Proc. IEEE Intl. Conf. on Robotics and Automation, Atlanta,* 1:909–16. Reprinted with permission.)

erate a near-uniform dose throughout the tumor volume and avoid irradiating nearby critical regions (66). Because the radiation sources are large and must follow precise trajectories, robots can be used as motion platforms for this application (Figure 8).

General and Thoracic Surgery

Many minimally invasive procedures in general and thoracic surgery share essential traits. The pertinent anatomy is approached via small incisions through the relatively thin (1–2 cm) abdominal or thoracic wall, accessing an open working volume. The incision acts as a pivot for tools that are relatively free to move inside the body; this pivot constraint poses many challenges in sensing and manipulation for the surgeon. Autonomous robots that use imaging data for guidance are not suitable for these applications because of the dexterity and variety of skills required for manipulating highly deformable soft tissue.

Because video endoscopes can provide direct visual access to the surgical site, surgeon-controlled teleoperated robots promise to help in a number of ways. Specialized mechanical designs add a ''wrist'' with additional joints near the instrument tip, which can rectify the motion constraint imposed by the incision

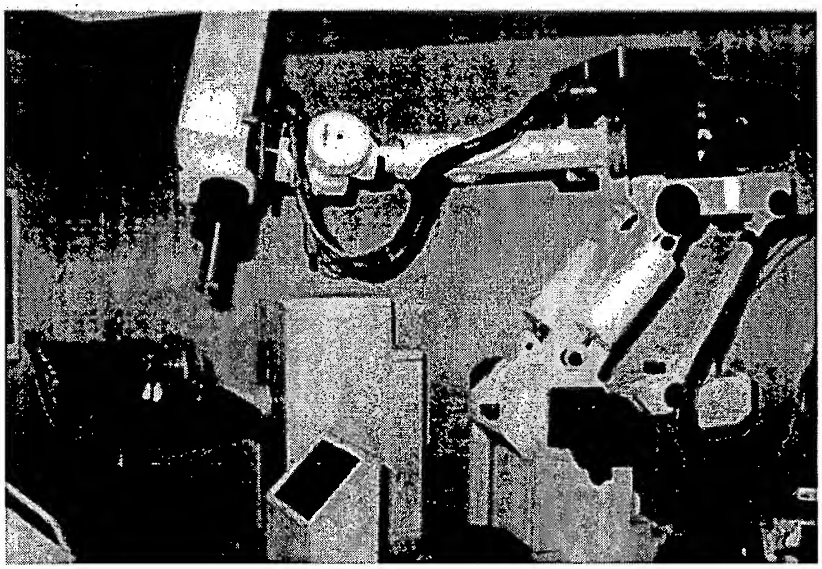

FIGURE 8 Radio surgery robot that uses a modified industrial robot as a motion platform for the large radiation source mounted at the end of the arm. (From Schweikard A, Adler JR, Latombe J-C. 1993. Motion planning in stereotaxic radiosurgery. *Proc. IEEE Intl. Conf. on Robotics and Automation, Atlanta,* 1:909–16. Reprinted with permission.)

(9, 31, 47). With these manipulators, surgeons can orient the instrument to arbitrary angles and reach around anatomical structures. Second, the controller can scale the surgeon's motions so that the robot works at smaller scale than is possible with hand-held instruments. This enables microsurgical procedures using minimally invasive techniques, as has been demonstrated for tubal anastomosis in heart bypass procedures (67, 73). A third advantage is that the control computer can interpose rotational transformations between the surgeon's master control interface and the surgical robot, so that, for example, orientations in the video image match motion direction at the surgeon's hands. Studies indicate that appropriate mappings can improve manipulation performance (42).

Teleoperation is also a promising approach for microsurgery in a number of specialties, including vascular, gynecological, neuro-, and ophthalmological surgery. A number of specialized systems have been developed (31, 64), in addition to the general-purpose telesurgical systems described above with motion scaling capabilities. These systems pose unique research problems, including development of specialized manipulators and grippers, control methods for optimal mapping between the human scale and microscales, and elimination of hand tremor (61, 63).

Minimally Invasive Surgery—Specialized Designs Specialized robotic systems can enable new procedures where access is limited to long lumens, as in gastrointestinal or urinary surgery. One example is transurethral resection of the prostate (30, 54). This procedure, to ameliorate benign enlargement of the prostate, is now a skilled manual process of inserting instruments through the urethra and removing tissue with repetitive cutting motions. In the system developed by Harris et al (30), the robotic system incorporates real-time ultrasonic imaging as well as cutting instruments. The surgeon uses the images to select the volume of the prostate to be excised. As with the ROBODOC system for hip surgery, the robot executes the planned resection autonomously, and the user interface provides the surgeon with continuous information about the progress of the procedure; the surgeon may halt or modify the procedure at any time. By developing a special-purpose mechanism, a number of safety features may be incorporated, including limiting the workspace accessible to the robot to the volume of the prostate, thus eliminating the possibility of more extensive tissue injury in the event of malfunction.

Another example of procedure-specialized mechanism design is robotic endoscopy. The most common application is colonoscopy, where the goal is inspection, biopsy, or treatment of the colon. Conventional endoscopes are rigid tubes, sometimes with a few manually operated joints. The limited articulation capabilities permit access only to the lower portion of the intestinal tract, and the limited conformation may produce large forces that cause considerable discomfort to the patient. There are two robotic approaches to endoscopes for these applications (58). One is a highly articulated mechanism with many joints that can conform to the sinuous passages of the bowel (35, 57). This approach requires incorpo-

rating a large number of actuators and sensors into the endoscope structure; size constraints suggest that novel technologies such as shape-memory alloy actuators may be useful here. Robotics research has only partially solved the problem of path planning and control algorithms for mechanisms with many redundant degrees of freedom.

The other approach is a miniature self-propelled robotic "vehicle," which has the potential to reach the entire gastrointestinal tract. The systems developed by Slatkin et al (71a, 72) and Carrozza et al (7) use an inchworm propulsion mechanism. Collars at the ends of each segment inflate to grip the colon wall, and extensors vary the distance between the collars (Figure 9). Activating these actuators in the correct sequence moves the robot forward or backward within the intestine. The robot trails an umbilical cable that provides power and control signals and returns video and other sensor information. The actuators use low-pressure pneumatic power to conform to the large variation in intestinal diameter

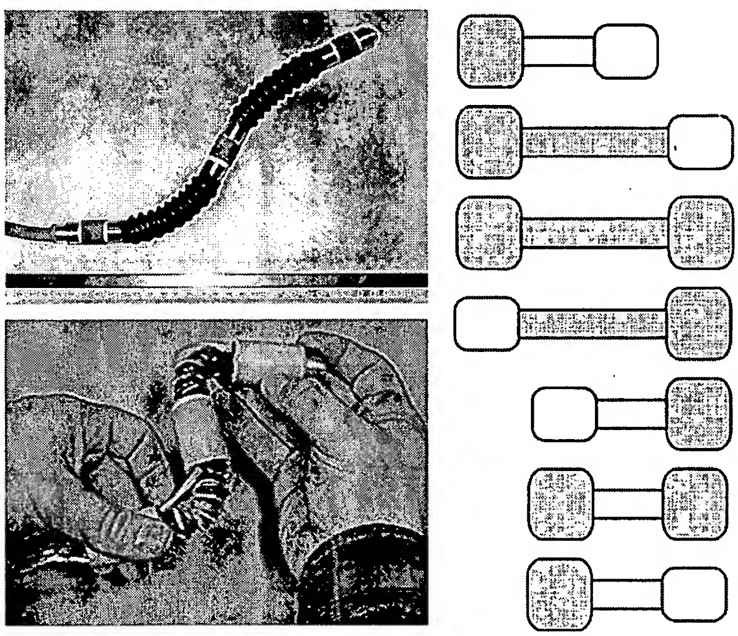

FIGURE 9 Self-propelled robot endoscope. (*Left*) Structure consists of flexible extensors joining inflatable collars, with a trailing umbilical for power and signal transmission. (*Right*) Once cycle of the inflation sequence for these actuators that moves the robot forward within the intestine. Inflated elements are shaded in each step. (Adapted from Slatkin AB, Burdick J, Grundfest W. 1995. The development of a robotic endoscope. In *Exp. Robotics IV. 4th Intl. Symp.*, ed. O Khatib, JK Salisbury, pp. 161–9. Berlin: Springer-Verlag. Reprinted with permission.)

and avoid concentrated local pressure on the intestinal wall. This also minimizes safety concerns associated with electrical actuation.

Another class of robotic system is designed for percutaneous needle puncture. Examples of procedures that are under development for robotics include draining fluid from the pericardial cavity (8) and the renal collecting system (74), and placing a pattern of radiation "seeds" for cancer treatment (6, 54). Some of these procedures are possible now with a manually inserted needle, but execution is difficult: Guidance is usually by 2-D images (ultrasound, X-ray, or fluoroscopy), and the surgeon must hit the small, deformable soft-tissue target and miss adjacent critical structures. New image-guided approaches use mechanical arms and multiple fluoroscopic views to aim the needle in three dimensions (59, 74) (Figure

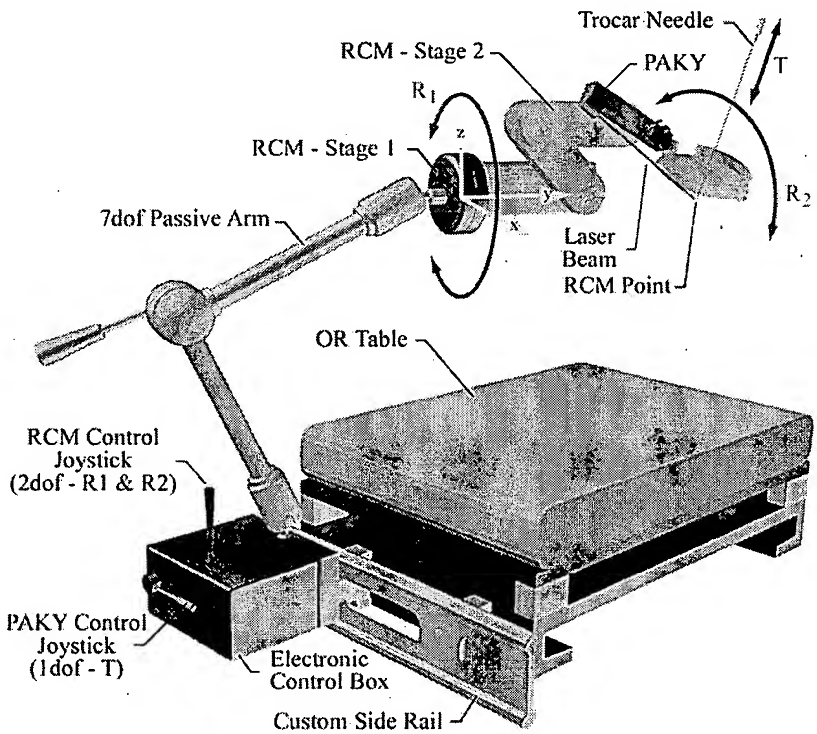

FIGURE 10 Robot for percutaneous needle puncture procedures. The lower joints are positioned and locked manually, while the upper stages are motorized. The needle positioner at the tip is transparent to X-rays to enable radiographic guidance. (From Stoianovici D, Whitcomb LL, Anderson JH, Russell RH, Kavoussi LR. 1998. A modular surgical robotic system for image guided percutaneous procedures. In *Proc. Med. Image Computing and Comp.-Assisted Intervention, Cambridge, Mass,* ed. WM Wells, A Colchester, S Delp, p. 404. Berlin: Springer-Verlag. Reprinted with permission.)

10). Another approach uses optical trackers on an ultrasound head, so a computer can reconstruct the 3-D anatomical structure (8). An optical tracker on the needle holder guides the surgeon to insert the needle into the target. Challenges in these procedures include the 2-D to 3-D registration problem, misregistration from motion of the patient as a result of respiration, heartbeat, or discomfort, deflection of the needle, and the development of intuitive computer interfaces for 3-D guidance.

Stability Enhancement Because robots are stable and untiring, they are effective assistants for a number of surgical procedures. One task that has received much attention is holding endoscopes for minimally invasive surgery. Several robotic systems for laparoscopic general surgery are now commercial products (1a, 21, 23). This function is particularly appealing for robotic implementation because contact with tissue is limited to the sides of the incision, so safety concerns and control complexity are minimized. Various methods for controlling scope pointing have been implemented, from simple instrument-mounted joysticks and foot pedals to voice commands (1a, 23) and head tracking (21). For neurosurgery, Gorodia et al (26) have demonstrated an assistive control system where the surgeon manually guides a robot-mounted endoscope. For procedures such as evacuation of hematomas, this approach may overcome problems with steadiness and precision when the endoscope is supported only by hand. Other applications where stability and lack of fatigue are important include limb holding (18) and organ retraction (60).

TRAINING AND SIMULATION

Robots are also finding applications in surgical training and simulation, where they provide force feedback from computer models of instrument–tissue interaction. In these systems, users manipulate surgical instrument handles that are attached to specialized robot manipulators (Figure 11; see color figure). A computer senses the user-generated motions and commands the robot to apply the forces that would have resulted from the instruments' interaction with real tissue. The computer also generates images of the simulated surgical site. These systems are similar to telesurgical systems where the user interacts with the master manipulator, but here a computer model replaces the actual surgical robot and patient. Systems have been developed for many procedures, including arthroscopic knee surgery (24), tubal anastomosis (56), and laparoscopic surgery (10).

These virtual environment systems offer a number of potential advantages. Compared with cadaver and animal training, costs may be reduced, and compared with conventional patient-based surgical training, there are fewer time and performance constraints. Because these systems measure all of the actions during each procedure, trainees can review their data to analyze technique, and trainers can evaluate progress and skill level. Finally, surgeons can explore new and

enhanced surgical techniques, and by incorporating preoperative image data, patient-specific procedures may be rehearsed.

The field of surgical simulation is still in an early state of development. Specialized "haptic interface" robots with sufficient fidelity to produce realistic sensations have been available for fewer than 10 years (13, 30a). One unsolved problem is tissue modeling. To determine the correct force to feed back in response to user motions, the system must calculate the deformation of model tissues in real time. Current mechanical modeling techniques, based on the finite-element method, are too slow for real-time use (1b, 10, 15a). In addition, the mechanical properties of many of the tissues of interest have not been measured. Another problem is generation of patient-specific models from 3-D image data. Gibson et al (24) have developed a voxel-based object representation scheme that operates directly on the medical image data structure. This approach can represent volumetric information that is hidden from the surface to allow realistic modeling of deformation, cutting, and tearing of tissues. Limitations of this approach include slow visual rendering and the need for more resolution for haptic feedback.

A central question for these systems is the relevance to actual surgery: Can a simulator effectively train medical students in good surgical skills? A report by O'Toole et al (56) suggests that the answer is yes. This study used a simulator to assess suturing technique. The user interface was a needle holder and forceps attached to force feedback devices (Figure 11). The user could see and feel simulated organs and interact with them in various ways (grasp, poke, pluck, and suture). Physics-based models made the vessels statically and dynamically realistic. Twelve medical students and eight practicing vascular surgeons performed large flexible-vessel anastomosis with the simulator. Their performance was evaluated in terms of errors, accuracy, and tissue damage. The average medical student's score was significantly worse than the average of practicing surgeons for most measures. In addition, performance improved more for the students during the study. Although these results demonstrate that untrained subjects learned the simulated surgical technique, the transference of skills to real surgery was not evaluated.

TECHNICAL AND IMPLEMENTATION CHALLENGES

The results reviewed above demonstrate that robotic technology can enhance surgery in many ways. Surgical robotics has been an active area of research for only a decade, and innovation continues at a rapid pace. In this concluding section, we review some of the leading research problems and consider issues that may constrain widespread clinical acceptance of robotic surgery.

Technical Issues

As discussed above, the great majority of surgical applications take advantage of the unique characteristics of robots. The main benefits may be summarized as improved precision, stability, and dexterity. To extend these benefits to additional procedures will require advances in mechanical design, sensing, and control.

Mechanical Design Currently, many image-guided surgical applications use off-the-shelf industrial robot manipulators. This speeds development and reduces costs, but these devices have not been optimized for the characteristics of specific surgical tasks. For example, most industrial robots are designed for good repeatability but may lack sufficient positional accuracy (38, 40). Similarly, assistive systems that share control between the robot and human surgeon would benefit from the development of low impedance manipulators in place of highly geared, stiff industrial arms (32, 79). Other advantages that can accrue to specialized designs include improved sterility and compatibility with imaging systems (e.g. transparency to X-rays). In teleoperated systems, access constraints have always necessitated the development of new manipulator configurations, but kinematic structures and actuator technologies are far from perfected. These technologies also limit the development of microrobots for medical applications (14).

Sensing and Control In teleoperated systems for minimally invasive or microsurgical procedures, there is substantial room for improvement of control and sensory feedback interfaces. In general, the human factors aspects of these systems have been little studied. Research questions include master manipulator configuration, mapping between master and remote robot coordinate systems, scaling laws for micromanipulation systems, and video, force, and tactile feedback fidelity and bandwidth requirements (31, 34, 42, 63, 67a, 68).

Image-guided procedures have been an area of great success for robotic surgery, but there are many unresolved issues. Improved automatic segmentation and planning systems promise to improve efficiency and accuracy. Areas for improvement in registration include elimination of invasively placed fiducials and methods for nonrigid registration and tracking of tissue deformation in real time. The use of 2-D imaging modalities such as ultrasound in combination with 3-D tracking may lower costs and enable wider application of image-guided techniques (8, 77).

For autonomous robotics in general, almost all successful applications over the past three decades have come in areas where tasks are narrowly specified and the environment is predictable, as in manufacturing. The early success of robotics in orthopedic surgery is due at least in part to the fact that bones are essentially rigid and relatively straightforward to manipulate, immobilize, and cut. The use of robots for autonomously manipulating soft tissue raises a host of new challenges, many without precedent in robotics research.

Currently, large deformation manipulation of soft tissue requires teleoperation, where the surgeon provides the required sensory integration and dexterous control. For autonomous robots to undertake these tasks will require good hand-eye coordination, tactile sensing of the instrument–tissue contact state, and an ability to predict the outcome of manipulative actions. Increased computational power has enabled new capabilities in "visual servoing" of manipulator motion, which begins to address the visual coordination problem (29, 34a). In contrast, integrating tactile information into control is still a largely unsolved problem in robotics, even for rigid objects (33). Alternative sensing schemes, such as real-time

continuous magnetic resonance imaging, may prove superior to visual and tactile approaches, but cost and manipulator compatibility issues are severe obstacles. Predicting the results of manipulative actions may require mechanical modeling of the tissue–instrument interaction. Initial research in this area for surgical simulation has showed that conventional techniques are far too slow for use in real-time control (10, 15a, 24).

In addition to these quantitative abilities, the actions of a skilled surgeon are based on broad and deep knowledge of anatomy and surgical technique. For complete autonomy, robots must be able to use such qualitative reasoning and broad sensory integration in control. This will require fundamental advances in several areas of computer science as well as robotics. As a more immediate goal, it may be possible to add semiautonomous capabilities that exploit the quantitative advantages of robots to decrease the demands on the surgeon, enable new procedures, and improve safety.

Clinical Implementation and Acceptance Issues

Safety Safety is an obvious concern for robotic surgery, and regulatory agencies require that it be addressed for every clinical implementation. As with most complex computer-controlled systems, there is no accepted technique that can guarantee safety for all systems in every circumstance (15, 55, 78). Various robotic systems approach the problem in different ways. One common technique is to include passive and active safety mechanisms in the mechanical design of the manipulator. A good example is the AESOP endoscopic pointing robot, used for minimally invasive general surgery (23). The end of the robot arm is attached to the endoscope through a gimbal and a magnetic coupling. Because the incision prevents lateral motion of the endoscope tube, as the robot moves the endoscope in space above the patient, the gimbal allows the endoscope tube to pivot about the incision. This makes it impossible for the robot to apply lateral forces on the incision. The magnetic coupling acts as an emergency release: If forces on the endoscope exceed the magnetic holding force, the endoscope disconnects and falls onto the patient's abdomen, which is unlikely to cause injury.

Examples of designed-in hardware safety features in other robot systems include the use of low-pressure pneumatic power to minimize dangers from electrical actuation (71a, 72), and limiting the size of the robot workspace to eliminate the possibility of damage to tissue away from the intended surgical site (30).

Safety features of the software portion of the system are also essential. In the context of a urology robot, Ng & Tan (55) used mathematical logic to analyze program flow and determine if it is possible for control to evade the safety features incorporated into the code. In addition, they implemented a completely independent safety monitor that can arrest a servo runaway and detect out-of-safe-boundary conditions, using joint encoder signals as input.

Some robotics developers have asserted that it is important to keep control of the procedure in the hands of the surgeon, even in image-guided surgery (32, 78).

For example, the knee surgery system developed by Ho et al (32) (see above) has the surgeon moving the cutting tool while the robot prevents motion outside of the planned workspace. In contrast, the ROBODOC hip replacement system has the robot moving the cutting tool under autonomous control while the surgeon monitors progress (36). Early results with ROBODOC from Europe suggest few problems with clinician acceptance of the autonomous control mode (2–4). As experience with robotic systems increases, the level of comfort with autonomous control may rise. It is, however, undeniably important to design user interfaces so that the surgeon is fully informed of the system's plans and status.

Other Acceptance Issues Robots will be successful in surgery only if they improve patient outcome, lower cost, or both. Unfortunately, in many cases outcome cannot be assessed until many years after the procedure. For example, it may take 15 years to accurately measure the difference in durability of robotic versus manual hip replacements. This is a prohibitive delay, both for the developers of the systems and for the patients who are denied this potentially improved care in the intervening years. As a result, an alternative measure of outcome may be necessary. In the hip replacement case, one measure is comparison of the closeness of the fit between the femur and the implant. As previous bone growth studies have shown that close fit is essential for good fixation, this is a plausible correlate with long-term success of the procedure. The space between the implant shaft and the bone can be measured radiographically soon after surgery, so this provides a means to measure outcome promptly, if indirectly, and facilitate more rapid acceptance. One benefit from early acceptance of robotic technology is that as the number of cases increases, clinicians often improve the procedure, which may result in better outcomes and lower costs (4).

Expense is also an issue with some robots. Although there is a large range in cost, some systems exceed one million dollars. This may reduce the rate of implementation, especially in the early years, when benefits have not been fully realized or documented. As the field matures and engineering expertise with these systems increases, costs will likely decrease. In addition, many robotic systems are now dedicated to specific procedures, so that systems for knee replacement are unable to perform hip replacements, even though the procedures are similar in many respects. With growing maturity of the field, systems may gain flexibility, so that the same robot can be used for a variety of procedures in a surgical specialty, serving to reduce costs.

Finally, we note that the progress reviewed here demonstrates that robotic technology will transform surgery in the coming years. Robots promise to become the standard modality for many common procedures, including hip replacement, heart bypass, and abdominal surgery. This suggests that surgeons, particularly researchers working to enhance and extend the field, will need to become familiar with robotic technology. The same is true for robotics researchers: Creating effective systems requires understanding the demands of surgical procedures and the culture of surgical practice. The research teams that have created groundbreaking

systems demanded close collaborations among robotics researchers, computer scientists, and surgeons. Future progress will require similar interdisciplinary teamwork.

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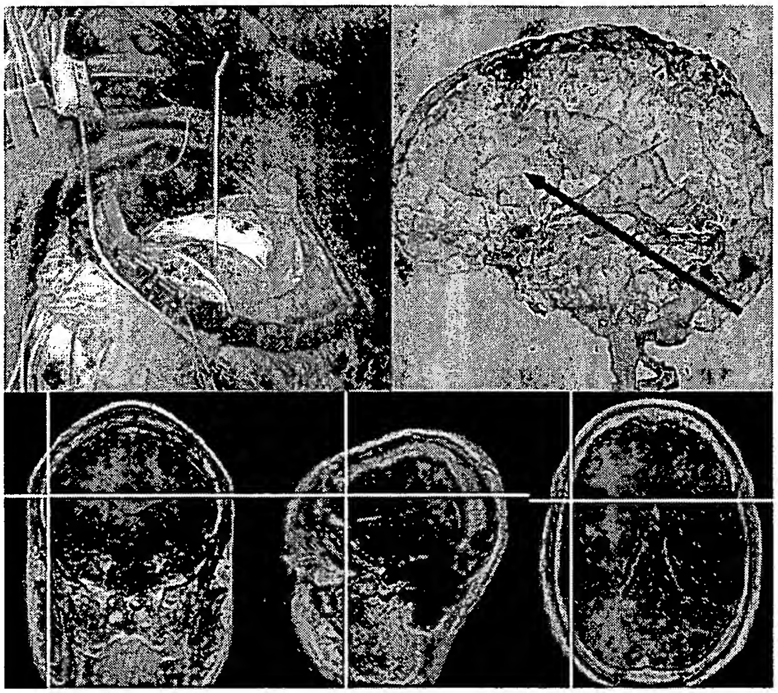

Figure 3 Image-guided neurosurgery planning and navigation system developed by MIT and Brigham and Women's Hospital. *(Upper left)* Photograph of operative field after craniotomy; optical markers on the hand-held probe at the center enable tracking and registration. *(Upper right)* Perspective view of segmented MR image data. Colors indicate normal (*gray, red, blue*) and pathological (*green*) brain structures. *Blue arrow* indicates probe location determined from real-time tracking data. *(Lower images)* Orthogonal views through MR data. Crosshairs show current probe tip location to assist in navigation. (Reprinted with permission from WEL Grimson, MIT.)

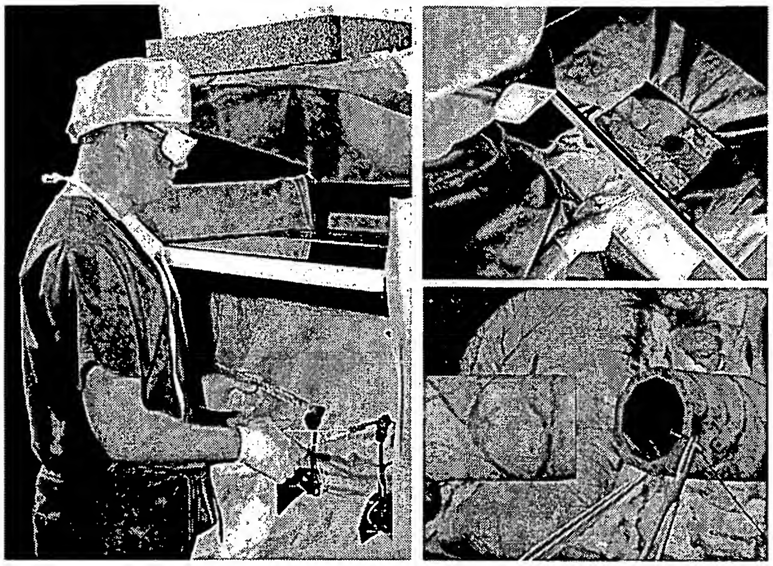

Figure 11 Surgical simulation training system for end-to-end anastomosis procedures. (*Left image*) Using a needle holder and forceps attached to force-feedback devices, the user can grasp, poke, pluck, and suture flexible vessels. (*Upper right*) A mirror arrangement superimposes the 3-D image of the operative field in the correct position relative to the surgeon's hands. (*Lower right*) Mechanics-based models generate forces and images that change realistically in response to contact. (From R O'Toole, R Playter, T Krummel, W Blank, N Cornelius, et al. Assessing Skill and Learning in Surgeons and Medical Students Using a Force Feedback Surgical Simulator. In *Proc. Med. Image Computing and Comp.-Assisted Intervention*, Cambridge, MA, 1998, p. 404. Ed. WM Wells, A Colchester, S Delp. Berlin: Springer-Verlag. Reprinted with permission.)

Medicine meets VR: 6

San Diego, January 1998

This, the sixth conference in the series on Medicine Meets VR, was very well attended, with an estimated 1,000 participants, from the US and Canada, Europe (Germany had a noticeable presence), and Asia (Japan, South Korea, Hong Kong, Singapore). This was a "high visibility" conference at which most of the key players were to be seen, presenting updates of their work.

The conference was a mixture of exhibition show and technical paper sessions. The quality of the technical presentations varied greatly, from interesting new technologies to introductory presentations such as "Applications of volumetric rendering in clinical practices". In general, I felt that there were far too many presentations: some 135, over four days. One had to switch madly between parallel sessions to get to hear papers that were arbitrarily classified under "technology" or "education". Paper acceptance is based on abstracts only, which explains the diversity to some extent, although there also seems to be a philosophy of breadth, rather than depth, in selecting contributions.

The first day was The Richard Satava Show. Col. Satava, MD, formerly with DARPA and now at Yale Medical School, is in charge of granting money to many projects on medical VR and is therefore at the centre of the community. His motto is "I have the vision, you guys realise it". He had two sessions to update the assembly on the progress of his grants: one about DARPA projects and the other about a new wave of funding from Yale-NASA (mostly the same projects that got funding from DARPA now getting the funding from Yale-NASA). They included:

- a "smart" T-shirt that senses the path of the bullet that hit its wearer, monitors his condition and location, etc., so that rescue teams can decide if he's worth rescuing, and be prepared, and combat units can knock out the location from which he was attacked;
- various personal monitoring devices, including a wearable system for astronauts;
- a Limb Trauma simulator using the PHANToM (by MusculoGraphics, in Boston);
- a stretcher with monitoring systems; and
- an enhanced dexterity robot called ParaDex.

In general, for the paper sessions, the presentations were too many to describe all in detail, were allocated only 15 minutes and – surprisingly – no questions were allowed.

Scientific And Clinical/Tools For Minimally Invasive Therapies

There were many endoscopic simulators, for the knee, shoulder, colon, abdomen ... And all had some force feedback that wasn't convincing as real tissue (from what doctors said) but apparently helped in training (from what the engineers said).

Tactile tissue simulation was one of the key phrases. Everybody is trying to figure out how to do it, but I didn't see (feel) any convincing implementation. Force feedback is the latest craze, but the sensitivity to model subtle gradations just isn't there yet. An interesting alternative is to use sound as feedback.

Also, many atlases of the whole human body (and one of a frog) were presented. Most used the Visible Human, but there were others (the Japanese) that had their own data sets.

One interesting point that was raised by the team at SRI is that the key problem in training surgeons is not how to convey the locomotive skills needed to manipulate an endoscope or to cut using a scalpel, but how to understand patient anatomy. Training the hands how to use an endoscope takes a week or so, but learning how to interpret a patient's anatomy takes years. I agree with this assessment, and I think that's where rich interaction capabilities combined with real-time volumetric rendering of multimodal data are crucial.

Highlights of the presentations

SRI, of Stanford, have tested their telepresence system with live animals using a 200 metre link. Their results are published in the Journal of Vascular Surgery. Dr. John Hill of SRI presented their first attempts to move towards computer-generated graphics training simulators using their telepresence system. They use a set-up similar to the ISS Virtual Workbench, but with their own interaction devices. They are working on simulating suture of tissue and vessels using an Onyx and 2D texture maps.

Ramin Shahidi, Stanford University Medical Center, is working on SGI-based volume rendering neurosurgery and craniofacial applications. Their graphics didn't include more than one volume at a time. His presentation was an overview of the use of volume rendering vs. surface rendering, and he didn't include the papers in the proceedings.

NASA-Ames and Stanford University have created the National Biocomputation Center: Dr Muriel Ross was announcing this centre as a resource for collaboration with academics and industry, to promote medical VR. NASA-Ames have an Immersion Workbench (aka Responsive Workbench, aka Immersadesk), and their own visualisation software, and are working on craniofacial "virtual" surgery. It appears that they use polygon meshes for their visualisation.

Henry Fuchs presented work in progress at UNC that uses depth range finders to reconstruct a surface map of the intestines to then guide an endoscope for colonoscopy. All this was added to their augmented reality system, and comprises an interestingly novel approach.

HT Medical presented their VR Simulation of Abdominal Trauma Surgery. They use the PHANToM and some "wet" graphics to remove a kidney. They simulate the "steps" taken by the surgeon. First the surgeon cuts the skin, which then opens, revealing the intestines. A wet graphics effect is used, but this looks more like "cling film" wrapping over everything. The intestines moved quite unconvincingly, in an animation that was slightly under the control of the user (it didn't appear like inverse kinematics were attaching the end-point of the intestines to the user's tool). The kidney

John Waterworth

was removed by simply "reaching into it" and moving it out. I couldn't quite see the point of such a simulation, frankly, unless trainee doctors don't realise that it's a good idea to cut into the abdomen before trying to remove a kidney.

On the other hand, I was very impressed by a paper from Wegner and Karron of Computer Aided Surgery Inc., which described the use of auditory feedback to guide blind biopsy needle placement. Their audio feedback system generates an error signal in 3D space with respect to a planned needle trajectory. This error signal and the preoperative plan are used to motivate a position sonification algorithm which generates appropriate sounds to guide the operator in needle placement. To put it simply, harmonics versus dissonances are used to convey position information accurately along 6–8 dimensions. A nice example of a synaesthetic medium – using one modality (sound) where one would normally expect another (touch and/or vision). Their approach has wide applicability.

Myron Kreuger is President of Artificial Reality Corporation and a claimant to the title of inventor of VR. He coined the term "Artificial Reality" (AR) in the early 1980s but, sadly for him, it didn't catch on – which is perhaps a pity. Here he was describing ARC's work on adding smells to VR. The system he described was a training system for dealing with emergencies, where smells of, for example, petrol, or the contents of the lower intestine, can provide valuable information in a hazardous situation. However, this work seems premature. Smells are messy – they involve molecules, not bits – and so tend to linger after they have been turned off.

Highlights of the exhibition

HT Medical demonstrated CathSim, a simulator that trains nursing students to perform vascular catheterisations. They built a special force feedback device and some simple graphics to provide visual feedback. It was quite good to guide the needle, but had little (no?) feedback once inside the skin. This seemed like "technological overkill" since the procedure is easily learned without VR and is not exactly hazardous.

They also demonstrated a Flexible Bronchoscopy simulator developed with a partnership of pulmonologists and pharmacology experts at Merck & Co. (based on the Visible Human Project). They have a way to track the flexible tip of the endoscope ("a secret", I was told when I asked) and they generate nice 2D texture-mapped graphics of the interior throat using an SRI Impact.

Fraunhofer had two demonstrations from their Providence office:

1. TeleInVivo, demonstrating a PC software volume renderer (a few seconds per rendering for small windows areas) attached to an ultrasound probe.
2. Interventional Ultrasound: a guiding system for biopsy needle insertion using an ultrasound tracking system (not much of an implementation at the moment), so it's the old idea of using ultrasound to guide a biopsy needle. They overlay the ultrasound view with the biopsy needle path, something that UNC demonstrated at SIGGRAPH, but without the expensive head gear.

Matthias Wapler, of the IPA branch in Stuttgart, described a robot for precise endoscopy and neurosurgical navigation. They have not yet developed planning software for their system.

Immersion Corp.: The people of Loral were at the Immersion booth, presenting a training system using the Immersion Corp.'s force feedback device. The application lets the surgeon guide an endoscope through the nose of a patient. The simulation was "helpful" to surgeons, although it is rather crude and doesn't feel like the real thing.

Prosolvia: A very tall Swede from Prosolvia (Swedish VR company) demonstrated a Virtual Arthroscopy of the shoulder, developed with University Hospital of Linkoping. They used the Immersion Corp. force feedback system, and their own Oxygen software base.

SensAble Technologies: Four demonstrations were shown at their booth:

1. The Ophthalmic surgical simulator. This project combines N-Vision US$25,000 stereo display (binoculars with 1280x1024 resolution; there is a cheaper version for VGA graphics at US$15,000) with the PHANToM, and a nice simulation of the feel of an eye. The computer platform is Intergraph. Since the PHANToM doesn't provide torque feedback, I didn't really appreciate the usefulness of the feedback system while cutting around the cornea. Poking the eye was more fun.
2. MusculoGraphics surgery simulation solutions. Their Limb Trauma simulator didn't have force feedback, so the PHANToM was used as a 3D pointer. The simulation consisted in picking up a bullet and stopping bleeding of a blood vessel. I thought the system was unrealistic and completely pointless.
3. Their IV catheter insertion system had force feedback, and was quite convincing.
4. Spine Biopsy Simulator, by the Georgetown University Medical School, for educational use. The aim is to mimic an actual spine biopsy procedure and improve overall learning by students. Unfortunately, their demo wasn't working.

Virtual Presence: This UK company presented two good tools.

1. VolWin, a volume rendering package (US$700) on the PC that is based on the Voxar API. The performance was really good, running on a plain PC. A 256x256x256 volume was rendered

Continued overleaf...

Medicine meets VR: 6

at some 5–6 fps, with some aliasing effects, but basically usable quality.

2. A package that tests the surgeon's performance using the Immersion Corp. laparoscopy device. No fancy graphics, the idea being to measure performance in hitting targets. Excellent simple idea for laparoscopy training.

Gold Standard Multimedia: They have produced a CD-ROM with a segmentation of the Visible Male. The package volume renders the views and structures chosen. On PC.

Sense8 medical customers are the National Centre for Biocomputation (NASA, Stanford U), Rutgers U, Center for Neuro-Science, and Iowa School of Dentistry.

A knee simulator was presented. Unfortunately, it broke early in the conference and before I could use it.

Vista Medical Technologies: Good head-mounted display to substitute for the microscope. Not head tracked, but it allows the surgeon to look through the microscope and outside. It also allows Picture-in-Picture, so that an endoscope can be used to supplement the microscope.

Lake Acoustics: There was a nice demonstration of 3D sonification from Lake, who were also involved in the 3D sound feedback for biopsy needle placement described briefly above (paper by Wegner and Karron). Using their kit, it is very simple to place sounds in a three-dimensional landscape surrounding the body to the front (as with normal stereo) and to the back (as with cinema surround sound) but using only headphones.

VR And Mental Health

There were several very interesting papers presented in this session, and a few peculiar ones. Unfortunately, few were included in the printed proceedings. It was clear that this is one of the medical areas where VR can most immediately and successfully be applied today. Topics included treatment of phobias, psychological assessment, and cognitive rehabilitation.

The session also provided an opportunity for the launch of the new "CyberPsychology and Behavior" journal, the first volume of which includes a useful summary of the use of VR as a therapeutic tool.

Brenda Wiederhold presented a good paper on using VR to go beyond the standard "imaginal" training of phobic patients. The advantages of VR are, first, that fear can be effectively activated (which is necessary to bring about change) but can be controlled (too much fear reinforces the phobia) and, second, physiological measures can be used to control the display. One simple measure of anxiety, first used by Jung, is a drop in skin resistance.

Similar work on claustrophobia and fear of heights was described by Bulligen of the University of Basle. Another paper on acrophobia (fear of heights) by Huang et al. of the University of Michigan described comparisons of real and virtual environments for emotional desensitisation, and questioned the need for a high level of realism. Using the CAVE environment, they compared the same views in VR and in reality. See their Web page for views [`http://www.umich.edu/~psychvr`].

A rather pleasant system from Japan, the "Bedside Wellness" system by Ohsuga et al., allows bedridden patients to take a virtual forest walk while lying on their backs in bed. An array of three video screens presents the unfolding view of the forest as the patient gently steps on two foot pedals. There is also 3D sound of birds, streams and wind in the trees. A slot below the central screen delivers a gentle breeze scented with pine to the "walking" patient.

Rizzo, of the University of Southern California, is using VR to give increased ecological validity to standard tests applied to Alzheimer's Disease patients, such as the mental rotation task (where the patient has to decide if a second figure is a rotated version of an earlier figure, or is different in shape). This Immersadesk application seemed like technological overkill to me. However, a fuller paper by Rizzo et al., in the CyberPsychology and Behavior journal, lists several advantages of VR for cognitive and functional assessment and rehabilitation applications:

1. ecologically valid and dynamic testing and training scenarios, difficult to present by other means
2. total control and consistency of administration
3. hierarchical and repetitive stimulus challenges that can be readily varied in complexity, depending on level of performance
4. provision of cueing stimuli or visualisation tactics to help successful performance in an errorless learning paradigm
5. immediate feedback of performance
6. ability to pause for discussion or instruction
7. option of self-guided exploration and independent testing and training
8. modification of sensory presentations and response requirements based on user's impairments
9. complete performance recording
10. more naturalistic and intuitive performance record for review and analysis by the user
11. safe environment, although realistic
12. ability to introduce game-like aspects to enhance motivation for learning
13. low-cost functional training environments

Also on the topic of psychological assessment, Laura Medozzi et al., from Milan, described what seemed to be high-quality work to compare traditional tests with VR-based testing. The case of a patient suffering frontal lobe dysfunction several years after a stroke was used to make the point that traditional tests often fail to reveal deficits that can be identified with VR. This is thought to be due to the nonverbal and immersive realism of VR, compared to the presence of a human examiner, in traditional testing, who inadvertently provided surrogate control over higher order

...continued from page 7

Interfaces 37
Oct 2002
...needed to **manipulate** an **endoscope** or to cut...telepresence **system** with live...intestines to then **guide** an **endoscope** for colonoscopy...augmented reality **system**, and comprises...feedback to **guide** blind biopsy...audio feedback **system** generates...

[http://www.bcs-hci.org.uk/interfaces/interfaces37.pdf]
similar results

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The KISMET 3D-Simulation Software

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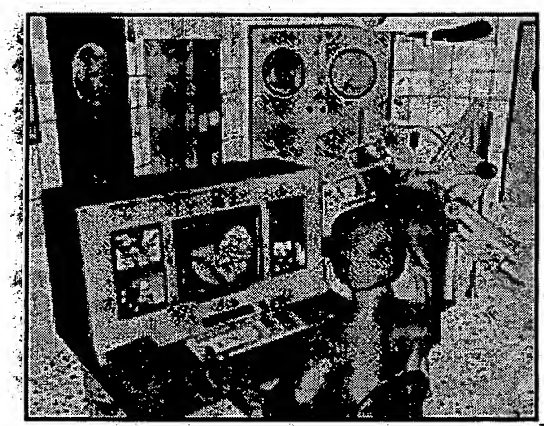
Last Update: **JULY 10, 2001**

Recent Additions:

- **Our NEW Virtual Endoscopic Surgery Training (VEST) system VS*One* is now available !**
  Read more about it here ! Last Update: JULY 10, 2001
- **Virtual Endoscopic Surgery Trainer for Gynaecology**
  Last Update: MAY 9, 2001

- **BMBF-Verbundprojekt HapticIO (in German)**
  Last Update: DECEMBER 21, 2000
- **The KISMET software is available for Windows NT 4.0 platforms**
  Last Update: DECEMBER 21, 2000
- **Updated KISMET V 6.0.3 User Manual in .pdf format for Download**
  Last Update: AUG 07, 1998
- **KISMET News Letter Last Update: DEC 21, 2000**
- **OpenGL based KISMET Version 6.0.3 for Download Last Update: JULY 22, 1999**
- **Noninvasive Measurement of living Tissue Elastodynamics Parameters April 1999**
- **Laparoscopic Surgery Trainer.**
- **Surgery Trainer Picture Gallery.**
- **KISMET Realtime Volume Rendering**
- **Force Feedback / Haptic User Interfaces**
- **Realtime Multibody Dynamics Simulation**



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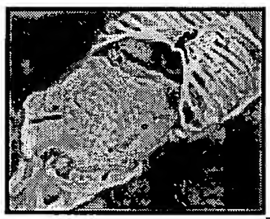
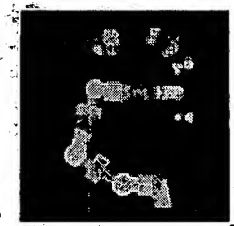
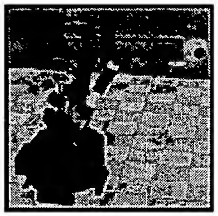
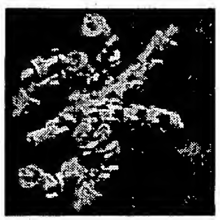
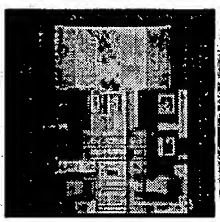
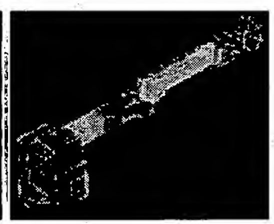
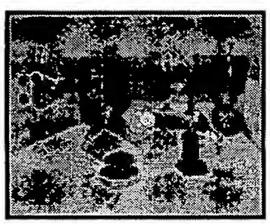
Overview

The KISMET (Kinematic Simulation, Monitoring and Off-Line Programming Environment for Telerobotics) software is under development at Forschungszentrum Karlsruhe since 1986 as a 3D realtime simulation support tool for:

- effective planning, simulating, programming and monitoring of teleoperation tasks
- robotics simulation
- high-performance graphical visualisation
- medical simulation
- Virtual-Reality (VR) application kernel
- scientific visualisation

KISMET Applications

-  Medical Simulation
- KISMET is integrated in the *ARTEMIS* (Advanced Robot and Telemanipulator System for Minimally Invasive Surgery) control system for MIS instrument and endoscope guidance as a 3D-graphical online position monitoring system.
- Multibody Dynamics Simulation
-  Remote Handling applications

-  **Space Telerobotics (800x800 image rotex.jpg, 49k)**
  KISMET was used at DLR-Oberpfaffenhofen as the major graphical user interface software kernel for the space robot technology experiment. ROTEX. It is still being used for other projects.
-  **Robotics Simulation**
-  **Mechanical Design**
-   **Scientific Visualisation**
-  **Just doing nice Graphics**

KISMET Features

- **Hierarchical data concept for interactive detail selection**
- **Sensor based synthetic viewing (Virtual Reality)**
- **Kinematic simulation of complex mechanisms**
- **Realtime multibody-system dynamics simulation**
- **Realtime elastodynamics simulation, tissue deformation**
- **High-quality rendering of polygonal, NURBS and voxel-volume geometry data models**
- **Camera simulation, model based control and target tracking**
- **Robot off-line programming and simulation**
- **Stereo viewing (shutter glasses)**
- **CAD data import tools (STEP, DXF, VDA-FS, Wavefront, SoftImage ...)**
- **KISMET is implemented in C, as graphics interface GL is used**
- **KISMET is available for SILICON GRAPHICS (TM) workstations**

KISMET Development Team

- **The people involved in the KISMET development**

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- VR Technology based Minimally Invasive Surgery Training

Jul 1997
...instruments **handling** of an **endoscope** mock-up with...formalised **methods** to model the...telesurgery **system** [2]. The kinematical...kinematical design **parameters**. The influence...invasive surgery **procedures** : Development...surgery training **system**. 3D-geometric...

[http://iregt1.iai.fzk.de/KISMET/docs/UKMITAT.html]

The Karlsruhe Endoscopic Surgery Trainer as an Example for Virtual Reality in Medical Education

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Forschungszentrum Karlsruhe GmbH, FRG

ABSTRACT

Virtual reality (VR) is a technology that can teach surgeons new procedures and can determine their level of competence before they operate on patients. An overview of the current state of development for the "Karlsruhe Endoscopic Surgery Trainer", a VR technology based training system for laparoscopic surgery, is presented. Special attention is addressed to geometric modelling techniques for graphical realtime performance and elastodynamically deformable tissue models.

Keywords: simulation, tissue modelling, deformable tissue models, VR-based surgery training

INTRODUCTION

Minimally invasive surgery (MIS) has been established among surgeons as an elective technique in a number of general surgery interventions. Endoscopic surgery of the abdomen, like gall-bladder and appendix removal, have now become commonly performed surgical operations. However, beneficial to the patients, these techniques require intensive training of the surgeons, practicing skills like 3D-orientation, hand-eye coordination and instrument handling. Surgical education has traditionally depended on the apprentice-mentor relationship and is the basis of residency training programs. Physical patient models like the pelvi-trainer lack realistic anatomical features. The concept of virtual reality (VR) surgical simulators is attracting considerable attention. Progress in computing performance allows the development of training systems for endoscopic surgery based on VR technology [3].

As a basis for our R&D activities, we use the 3D-graphical simulation program KISMET [1] (**K**inematic **S**imulation, **M**onitoring and Off-Line Programming **E**nvironment for **T**elerobotics), which has been under development at Forschungszentrum Karlsruhe (FZK) for a number of applications. Because of its high quality realtime graphics capabilities and additional features like geometrical and kinematical modelling, multibody-dynamics, and its database concept allowing for multiple detail-levels, it was found to be an ideal platform for computer aided surgical simulation. The software has been improved significantly during the past years to meet the specific requirements of physical model based minimally invasive surgery simulation. Using the advanced capabilities of high-performance graphical workstations combined with state-of-the-art simulation techniques, it is possible to generate virtual endoscopic views of surgical scenarios with high realism.

The "Karlsruhe Endoscopic Trainer"

The MIS trainer produces a synthetic mono or stereo image of the view, which is in reality provided by the endoscopic camera [Fig. 4]. As a surgeon-computer interface, a "Mechano/Electrical Box" was developed as an artificial cavity together with the correct instrument set so that the interface normally presented to the surgeon is maintained using a physical simulation. This set-up [Figs. 1, 2, 3] enables following practical exercises:

- coordination of different instruments
- handling of an endoscope mock-up with its corresponding synthetic camera view
- teamwork of surgeon, assistant and cameraman
- simulation of new instrument designs and manipulator control devices
- measurement of handling speeds in a simulated environment

The design concept of the Karlsruhe Virtual Endoscopic Surgery Trainer takes into account the kinematics of conventional endoscopic handling with four degrees of freedom. Furthermore it allows for future extension of the training interface with dexterous instruments with 6 or more joints, i.e. kinematically redundant mechanisms. We have developed simulation techniques which allow the modelling of "virtual tissue" based on a data-model which reflects the physical characteristics of like mass, stiffness and damping of real living tissue. A collision test algorithm detects contact between surgical instruments and the manipulated virtual objects. As a by-product, contact forces between the tissue and the instrument end-effector are calculated which can be used in future surgeon interfaces to drive force-reflecting input devices. An advanced interaction module allows grabbing, cutting, clipping [Fig.4]. and coagulation of virtual tissue and "organs".

The trainee surgeon manipulates the instruments in the normal way, and in our case the movements are transferred to the graphics workstation by means of a PC-based joint angle measurement system. The PC provides up to 48 analog 12-Bit input channels and 32-Bits digital input for foot switches. The sensor data are transferred with 30 Hz to the graphics station by means of asynchronous RS-232 communications. We use potentiometers hinged to all internal instrument degrees of freedom together with custom designed and manufactured mechanics inside the "Box" to aquire the relative joint positions. On request of the graphical workstation, the signals are submitted via serial Interface with 38400 Bits/sec. The maximum response time delay for aquisition and transmission of one data block is less than 30 ms. In addition to the instrument box, several foot switches are used to control surgical interactions (coagulation) and system control functions (model reset, instrument change).

SIMULATION TECHNIQUES AND MATHEMATICAL FRAMEWORK

KISMET is implemented under the UNIX operating system on SILICON GRAPHICS 4D (SGI) high-performance graphics workstations. This configuration allows for synthetic generation of any view in a surgical simulation with interactive rates, depending on the complexity of the models. In our demonstrator, 20 images per second are calculated, using an SGI-Onyx RE2 workstation with two 200 MHz Mips-R4400 CPU's. Multiple window display and stereoscopic viewing using shutter glasses are supported by KISMET as display options. The objects can be rendered in high quality shaded modes with surface texture, as wireframes, or as transparent models. The display mode can be set interactively as an object attribute for any part and/or for groups of parts.

Our research and software development is currently directed to the simulation of realistic interactions between surgical tools and the organs, which are modelled as deformable bodies [Fig.5]. We have developed simulation techniques which allow the modelling of "virtual tissue" based on a data-model which reflects the physical characteristics like mass, stiffness and damping of real tissue [4]. Virtual organs are modelled in KISMET as elastic NURBS objects. The control points of the NURBS surface form together with additional nodes an elastic mesh of virtual mass points, which are interconnected by springs. The equation of motion for the dynamic spring/mass-node system is solved by discrete integration as a coupled system of second order ordinary differential equations

$$m_i \frac{d^2 \underline{x}_i}{dt^2} + \gamma_i \frac{d\underline{x}_i}{dt} + \underline{g}_i = \underline{f}_i \quad (1)$$

A collision test algorithm detects contact between surgical instruments and the virtual organs. The algorithm allows for realtime simulation of tissue elasticity. The algorithm used in KISMET allows for realistic interaction (deformations) between surgical instruments and tissue surfaces in the virtual surgery scenario. As a by-product, contact forces between the tissue surface and the instrument end-effector are calculated, which can be used to drive a force-reflecting surgeon interface. This feature will be used for future tactile feedback in our MIS trainer.

MODELING AND SIMULATION OF SURGICAL SCENARIOS

The kinematics of a mechanical manipulator can be modelled in KISMET as an open or closed-loop articulated chain with several rigid bodies (links) connected in series by either revolute or prismatic joints, driven by actuators. High-level joints (planar, spheric etc.) are modelled with combinations of the two basic types. We use formalised methods to model the kinematical structure of mechanisms to provide a systematic and generalised approach to define and calculate mechanism motion with respect to a fixed reference frame. Thus, KISMET was used at FZK to support the design of the instruments and medical manipulators used in the ARTEMIS telesurgery system [2]. The kinematical simulation of these multi-link mechanisms allows detailed studies during the design stage. The behaviour of these mechanisms can easily be modified by interactive modification of the kinematical design parameters. The influence of machining errors in the range of microns has been studied with KISMET by a tolerance analysis. Geometrical optimisation has been carried out in order to avoid internal collisions in the mechanisms.

Geometrical models of the surgical environment, i.e. the organs, cannot be easily modelled with regular shape primitives. We have used commercially available free-form surface modelers for tissue modeling. In close cooperation with medical staff from University Tübingen (Prof. Buess), we have developed surgical scenarios of the human digestive system and another one of the upper abdominal organs which is mainly used in the laparascopic surgery trainer project showing the organs and conventional instruments relevant for the colecystectomy operation (removal of the gall-bladder).

For tissue modelling we use in KISMET hybrid polyhedron and NURBS-geometry representations. Additionally we have developed a program (CREATOR) to generate simple geometric datasets (a cushion like geometry and tubes) together with the physical properties for

elastodynamical simulation. These simple shapes are further interactively edited with KISMET to create the final shape of the "organs".

Another research topic is an interface to KISMET from volume (voxel) based systems as used for display of CT- and MRI-datasets. Such an interface is mandatory for modeling the unique anatomy of a specific patient.

CONCLUSION

It was demonstrated that KISMET can be used effectively in medical virtual reality scenarios with high graphical realism during planning, teaching and surveillance of minimally invasive surgery procedures :

- Development of a Virtual Reality abdominal surgery training system.
- 3D-geometric, kinematic and multibody-dynamics simulation, animation and analysis of complex mechanisms during the design phase of new surgical instruments and medical manipulators
- Operation room scenario simulation
- Realtime visualisation of voxel-volume datasets using 3D-texturing techniques
- High-quality 3D-models of the human abdominal anatomy have been created

ACKNOWLEDGEMENT

We greatfully acknowledge the medical advice given by Prof. G. Buess and his team from Minimal Invasive Surgery at Universitätsklinikum Tübingen/FRG.

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List of Figures

Fig. 1: Karlsruhe Endoscopic Virtual Surgery Trainer

Fig. 2: Component overview

Fig. 3: Instrument box

Fig. 4: Simulated endoscopic view inside the virtual abdomen

Fig. 5: Deformable tissue modelled with virtual massknots and connecting springs

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Medical Image Analysis
Volume 4, Issue 1 , March 2000, Pages 57-66

doi:10.1016/S1361-8415(00)00002-5 Cite or link using doi

Modelling of soft tissue deformation for laparoscopic surgery simulation

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Received 22 September 1998; revised 12 July 1999; accepted 22 July 1999. ; Available online 19 July 2000.

Abstract

Virtual reality based surgical simulator systems offer a very elegant solution to the development of endoscopic surgical trainers. While the graphical performance of commercial systems already makes PC-based simulators viable, the real-time simulation of soft tissue deformation is still the major obstacle in developing simulators for soft-tissue surgery. The goal of the present work is to develop a framework for the full-scale, real-time, finite element simulation of elastic tissue deformation in complex systems such as the human abdomen. The key for such a development is the proper formulation of the model, the development of scalable parallel solution algorithms, and special-purpose parallel hardware. The developed techniques will be used for the implementation of a gynecological laparoscopic VR-trainer

system.

Author Keywords: Soft tissue deformation; Surgery simulation; Minimal invasive surgery

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Medical Image Analysis
Volume 4, Issue 1 , March 2000, Pages 57-66

.VIRIM: A massively parallel processor for real-time volume visualization in medicine
Gunther, T. / Poliwoda, C. / Reinhart, C. / Hesser, J. / Manner, R. / Meinzer, H.-P. / Baur, H.-J., *Computers & Graphics*, Sep 1995
...other two **methods**. Compared...use for our **system**. In the following...pipeline **processor** is described...coordinate are **handled** separately...into control **parameters** like rotation...structure that **handles** all communica...visualization **system**. Due to the...DSP-board, and it **handles** all communication...actively their **parameters** from the...application for the **system** described...digital **endoscope**', enabling...

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Computers & Graphics
Volume 19, Issue 5 , September-October 1995, Pages 705-710

doi:10.1016/0097-8493(95)00049-6 Cite or link using doi

VIRIM: A massively parallel processor for real-time volume visualization in medicine

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Available online 13 January 2000.

Abstract

Architecture and applications of a massively parallel system currently developed are described, which allows real-time visualization using volume oriented visualization algorithms. Volumes of 256 × 256 × 128 voxels can be visualized with a frame rate of 10 Hz. The system is scalable and modular, and will allow a multi-user access over high-speed networks. 3D-rotation around arbitrary rotation axis, perspective, zooming and arbitrary grey value mapping are provided in real-time. A volume oriented algorithm is used that is tailored to the requirements in medicine [H.-P. Meinzer *et al., IEEE Comp. Graph. Appl.*, 34 (Nov. 1991)]. With this algorithm, small structures without defined surfaces, *e.g.*, tumours, can be

visualized as well as semi-transparent objects. One planned application of the system is heart surgery.

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* Corresponding author.

Computers & Graphics
Volume 19, Issue 5 , September-October 1995, Pages 705-710

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IEEE Virtual Reality 2000 Conference
March 18 - 22, 2000
New Brunswick, New Jersey

p. 284 • A Six DOF Haptic Interface for Medical Virtual Reality Applications: Design, Control and Human Factors

Abderraouf Benali, Philippe Bidaud, **LRP**
Paul Richard , **CRIIF**

Web Abstract: In this paper we present a haptic interface dedicated to endoscopic training, where the endoscope is allowed to react to contact forces along six degrees of freedom. The model takes into account end point position and appropriate contact forces. The illusion of physical movement inside the environment is obtained by computing control inputs based on impedance environment. Then, the user can manipulate and react with the virtual simulated environment. The LRP Haptic Impedance System (HIS), is a desk-top force feedback system that provides six degrees of freedom (DOF) force and torque sensing capabilities along the motion directions. A six-DOF force sensor is placed directly between the handle and the top of Stewart platform and is electrically connected to the controller via the A/D board converter. Three basic experiments were designed in order to investigate operator's ability to control and minimize the interaction forces between the tool end effector and a stiff surface during executing endoscopic primitive.

Index Terms- endoscope, haptic interface, force feedback, impedance control, Stewart platform

.Hybrid Methods Using Evolutionary Algorithms for On-Line Training
Feb 2002
...autonomous vehicle **system** under various...abundance of **methods** for learning...straightforwardly **handle** nonstationary...backpropagation **method** [17]. This...strate- gies can **handle** non differentiable...chosen control **parameters**. Experimental...controls the **endoscope**'s direction...extraction **process** [9]. In our...

[http://www.brunel.ac.uk/~csstgdm/366.pdf]

Hybrid Methods Using Evolutionary Algorithms for On–line Training

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Abstract

A novel hybrid evolutionary approach is presented in this paper for improving the performance of neural network classifiers in slowly varying environments. For this purpose, we investigate a coupling of Differential Evolution Strategy and Stochastic Gradient Descent, using both the global search capabilities of Evolutionary Strategies and the effectiveness of on–line gradient descent. The use of Differential Evolution Strategy is related to the concept of evolution of a number of individuals from generation to generation and that of on–line gradient descent to the concept of adaptation to the environment by learning. The hybrid algorithm is tested in two real-life image processing applications. Experimental results suggest that the hybrid strategy is capable to train on–line effectively leading to networks with increased generalization capability.

1 Introduction

Learning in Artificial neural Networks (ANNs) is usually achieved by minimizing the network's error, which is a measure of its performance, and is defined as the difference between the actual output vector of the network and the desired one. This approach is very popular for training ANNs and includes training algorithms that can be divided in two categories: batch, also called off–line, and stochastic, also called on–line.

The batch training of ANNs is considered as the classical machine learning approach: a set of examples is used for learning a good approximating function, i.e. train the ANN, before the network is used in the application. Batch training is consistent with the theory of unconstrained optimization and can be viewed as the minimization of the function E; that is to find a set of weights $w^* = (w_1^*, w_2^*, \ldots, w_n^*) \in \mathbb{R}^n$, such that:

$$w^* = \min_{w \in \mathbb{R}^n} E(w), \qquad (1)$$

where E is the batch error measure defined as the sum–of–squared–differences error function over the entire training set.

The rapid computation of such a minimizer is a rather difficult task since, in general, the dimension of parameter space is high and the error function generates a complicated surface in this space, possessing multitudes of local minima and having broad flat regions adjoined to narrow steep ones that need to be searched to locate an "optimal" weight set.

On the other hand, in on–line training, the function E is pattern-based and is defined as the instantaneous squared–differences error function with respect to the currently presented training pattern. In this case, the ANN weights are updated after the presentation of each training example, which may be sampled with or without repetition. On–line training may be the appropriate choice for learning a task, either because of the very large (or even redundant) training set, or because of the slowly time–varying nature of the task. Moreover, it helps escaping local minima and provides a more natural approach for learning time varying functions and continuously adapt in a changing environment. As Sutton pointed out, [24], "on–line learning is essential if we want to obtain learning systems as opposed to merely

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learned ones".

In practice, on–line methods seem to be more robust than batch methods as errors, omissions or redundant data in the training set can be corrected or ejected during the training phase. Additionally, training data can often be generated easily and in great quantities when the system is in operation, whereas they are usually scarce and precious before. Furthermore, on–line training, and/or on–line retraining, of ANNs is very important in many real–time reactive environments. For example, when we require to control the steering direction of a autonomous vehicle system under various road conditions [5], or recognize, detect and extract objects in images and video sequences under variable perceptual conditions (shading, shadows, lighting conditions, and reflections) [4, 7, 13, 14, 27].

Despite the abundance of methods for learning from examples, there are only few that can be used effectively for on–line learning. For example, the classic batch training algorithms cannot straightforwardly handle nonstationary data. Even when some of them are used in on–line training there exists the problem of "catastrophic interference", in which training on new examples interferes excessively with previously learned examples leading to saturation and slow convergence [25]. Note that in this context it is not possible to use advanced optimization methods, such as conjugate gradient, variable metric, simulated annealing etc., as these methods rely on a fixed error surface [19]. Consequently, given the inherent efficiency of stochastic gradient descent, various schemes have been recently proposed based on this idea, [2, 19, 21, 22, 24]. However, these schemes suffer from several drawbacks, such as sensitivity to learning parameters [19].

This paper proposes a new Hybrid Evolutionary Algorithm (HEA) for on–line training. The HEA could conceptually be split-up into two stages. In the first stage, on–line training is adopted using a recently proposed stochastic gradient descent with adaptive stepsize [11]. In the second stage, a Differential Evolution (DE) Strategy, [23], is used for on–line retraining. The usage of DE Strategy is based on the assumption that the first stage has produced a "good" solution that can be incorporated directly into the genes and inherited by offspring.

The rest of the paper is organized as follows: the use of Evolutionary Algorithms in ANNs training is discussed in Section 2. In Section 3, the new hybrid on–line training algorithm is introduced. Section 4 presents details on the application of the hybrid method in training on–line ANNs for real-life image recognition problems and outlines the implementation results. Finally, in Section 5, conclusions and a short discussion of future work are presented.

2 Evolutionary Algorithms in ANN Training

Evolutionary Algorithms (EAs) are stochastic search methods that mimic the metaphor of natural biological evolution. They operate on a population of potential solutions applying the principle of survival of the fittest to produce better and better approximations to a solution. At each generation, a new set of approximations is created by the process of selecting individuals according to their level of fitness in the problem domain and breeding them together using operators borrowed from natural genetics [3]. Many attempts have been made within the artificial intelligence community to integrate EAs and ANNs. A number of attempts has concentrated on applying evolutionary principles to improve the generalization of ANNs, discover the appropriate network topology, and the best available set of weights (see [18]).

The majority of approaches in which evolutionary principles are used in conjunction with ANN training formulates the problem of finding the weights of a fixed neural architecture, when the whole set of examples is available, as an optimization problem. EAs are global search methods and, thus, less susceptible to local minima [16]. Nevertheless, EAs remain, in certain cases, more computationally expensive than training by a variant of the backpropagation method [17]. This is one of the reasons that narrow the applicability of EAs to off–line ANN training.

In previous work, we demonstrated the efficiency of a special class of EAs, called *Differential Evolution* (DE) strategies, [12, 23], in off–line training [15]. DE strategies can handle non differentiable, nonlinear and multimodal objective functions efficiently, and require few easily chosen control parameters. Experimental results have shown that DE strategies have good convergence properties and outperform other evolutionary algorithms [15].

To apply DE strategies to ANN training we start with a specific number (NP) of n–dimensional weight vectors, as an initial weight population, and evolve them over time; NP is fixed throughout the training process and the weight population is initialized randomly following a uniform probability distribution. At each iteration, called *generation*, new weight vectors are generated by the combination of weight vectors randomly chosen

from the population. This operation is called *mutation*. The outcoming weight vectors are then mixed with another predetermined weight vector – the target vector – and this operation is called *crossover*. This operation yields the so–called trial vector. The trial vector is accepted for the next generation if and only if it reduces the value of the error function E. This last operation is called *selection*. The above mentioned operations introduce diversity in the population and are used to help the algorithm escape the local minima in the weight space. The combined action of mutation and crossover is responsible for much of the effectiveness of DE's search, and allows them to act as parallel, noise–tolerant hill–climbing algorithms, which efficiently search the whole weight space.

As in this work we focus on the on–line training and retraining of ANNs, we adopt a formulation of this problem which is based on tracking the changing location of the minimum of a pattern-based, and, thus, dynamically changing, error function. This approach coincides with the way adaptation in the evolutionary time scale is considered [20], and allows us to explore and expand further research on the tracking performance of evolution strategies and genetic algorithms [1, 20, 26].

3 The Hybrid Evolutionary Algorithm

In this section, we present a Lamarck–inspired combination of Differential Evolution strategy and Stochastic Gradient Descent (SGD). The DE strategy works on the termination point of the SGD. Thus, the method consists of a SGD–based on–line training stage and an Evolutionary strategy–based on–line retraining stage.

A generic description of the proposed hybrid algorithm, is given in Algorithm 1. First, the SGD is outlined in the Stage 1 of Algorithm 1, where η is the stepsize, K is the meta–stepsize and $\langle \cdot, \cdot \rangle$ stands for the usual inner product in $\mathbb{R}^n$. The memory–based calculation of the stepsize, in Step 4a, takes into consideration previously computed pieces of information to adapt the stepsize for the next pattern presentation. This provides some kind of stabilization in the calculated values of the stepsize, and helps the stochastic gradient descent to exhibit fast convergence and high success rate. Note that the classification error, an upper limit to the error function evaluations, or a pattern-based error measure can be used as the termination condition in Step 5a. The key features of the SGD method are the low storage requirements and the inexpensive computations. Moreover, in order to calculate the stepsize to be used at the next iteration, this on–line algorithm uses information from the current, as well as the previous iteration.

In Stage 2 of Algorithm 1, the DE strategy, responsible for the on–line retraining is outlined. Steps 3b and 4b implement the mutation and crossover operators, respectively, while Step 5b is the selection operator.

The first DE operator used is the mutation operator. Specifically, for each weight vector w_i^p, a new vector called mutant vector is generated according to the following relation:

$$\text{Mutant\_Vector} = w_i^p + \xi(w_{best} - w_i^p) + \xi(w_{r_1} - w_{r_2}),$$

where w_{best} is the best member of the previous generation, $\xi > 0$ is a real parameter called mutation constant and controls the amplification of the difference between two weight vectors, and w_{r_1} and w_{r_2} are two randomly chosen weight vectors, different from w_i^p.

To increase further the diversity of the mutant weight vector, the crossover operator is applied. Specifically, for each component $j, (j = 1, 2, \ldots, n)$, of the mutant weight vector, we randomly choose a real number r from the interval $[0, 1]$. Then, we compare this number with $\rho > 0$ (crossover constant), and if $r \leqslant \rho$ we select, as the j-th component of the trial vector, the corresponding component j of the mutant vector. Otherwise, we pick the j-th component of the target vector.

4 Experiments and Results

We have tested the proposed hybrid algorithm in two real–life classification tasks. The first experiment concerns training on–line an ANN classifier to discriminate among 12 texture images, and the second one, training an ANN to detect suspicious regions in colonoscopic video sequences. In all cases, no operation for tuning the mutation and crossover constants was carried out; default fixed values $\xi = 0.5$ and $\rho = 0.7$ have been used.

4.1 The texture classification problem

A total of 12 Brodatz texture images of size 512×512, [6], as shown in Figure 1, was acquired by a scanner at 150dpi. From each texture image, 10 subimages of size 128×128 were randomly selected, and the co–occurrence method, [8], was applied. In the co–occurrence method, the relative frequencies of gray–level pairs of pixels at certain relative displacements are computed and stored in a matrix. The combination of the nearest neighbor pairs at orientations 0^o, 45^o, 90^o and 135^o is used in the experiment. A set

	Stage 1 - "Learning"
Step 0a:	Initialize the weights w^0, η^0 and the meta-stepsize K.
Step 1a:	**Repeat** for each pattern p.
Step 2a:	Calculate $E(w^p)$ and then $\nabla E(w^p)$.
Step 3a:	Update the weights: $w^{p+1} = w^p - \eta^p \nabla E(w^p)$.
Step 4a:	Calculate the stepsize to be used with the next pattern $p+1$: $\eta^{p+1} = \eta^p + K \langle \nabla E(w^{p-1}), \nabla E(w^p) \rangle$.
Step 5a:	**Until** the termination condition is met.
Step 6a:	**Return** the final weights w^{p+1} to the Stage 2.
	Stage 2 - "Evolution"
Step 0b:	Initialize the DE population in the neighborhood of w^{p+1}.
Step 1b:	**Repeat** for each input pattern p.
Step 2b:	**For** $i = 1$ to NP
Step 3b:	MUTATION(w_i^p) → Mutant_Vector.
Step 4b:	CROSSOVER(Mutant_Vector) → Trial_Vector.
Step 5b:	**If** E(Trial_Vector) $\leqslant E(w_i^p)$, accept Trial_Vector for the next generation.
Step 6b:	**EndFor**
Step 7b:	**Until** the termination condition is met.

Algorithm 1: Generic Model of the Hybrid On–line Training Algorithm

of 10 sixteenth–dimensional training patterns was extracted from each image.

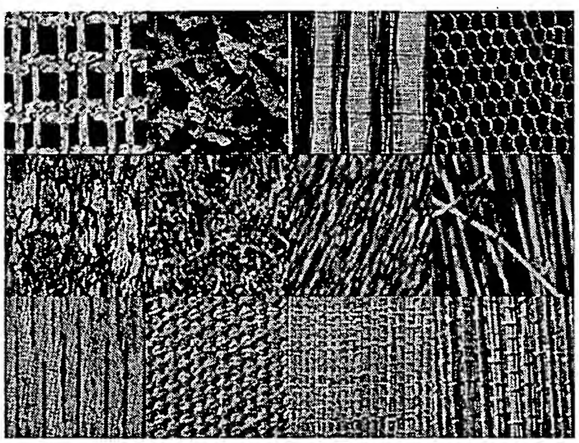

Figure 1: The twelve texture images.

A 16–8–12 ANN (224 weights, 20 biases) was trained on–line to classify the patterns into the 12 texture types. The network used neurons of logistic activations with biases, and the weights and biases were initialized with random numbers from the interval $(-1, 1)$. The termination condition for the first stage was a classification error $CE \leqslant 3\%$. Then, the second stage was executed for on–line retaining using new patterns from the training set. At the end, the generalization capability of the trained network was tested on the test set, which consisted of 320 patterns (20 patterns from each image extracted from randomly selected subimages). The ANN correctly classified 304 out of 320 patterns. Thus, it exhibited 95% generalization success. In the same task, the performance of the SGD alone, i.e. without using the evolution stage of the algorithm for the on–line retraining, was 93%, while the performance of the batch backpropagation algorithm with variable stepsize, [10], was 90%.

4.2 Abnormalities detection by colonoscopy

Colonoscopy is a minimal invasive technique for the production of medical images. A narrow pipe like structure, an endoscope, is passed into the patient's body. Video endoscopes have small cameras in their tips. When passed into a body, what the camera observes is displayed on a television monitor (see Figure 2 for a sample frame of the video sequence). The physician controls the endoscope's direction using wheels and buttons. An important stage of the implementation is the feature extraction process [9]. In our experiments we have used the co–occurrence matrices to generate features. More specifically, each frame of the endoscopic video sequence was separated into windows of size 16 pixels by 16 pixels. Then, the co–occurrence matrices algorithm was used to gather information regarding each pixel in an image window, and to generate feature vectors that contain sixteen elements each.

A 16–30–2 ANN (540 weights, 32 biases) with logistic

activations was trained on–line to discriminate between normal and suspicious image regions using 300 randomly selected patterns from the first frame. On–line training stopped when the ANN exhibited 3% misclassifications on the training set. It must be noted that the first stage was extremely fast; approximately 40 training epochs were needed. For on–line retraining, the DE population has been initialized with weight vectors in the neighborhood of the weight vector obtained from the first stage. In order to test the tracking performance of the hybrid algorithm, we introduced in the training set patterns from other frames of the same video sequence, which exhibited resolution change, different perceptual direction of the physician, different diffused light conditions. Thus, on–line retraining was performed using a training set of 1200 patterns. The DE algorithm was allowed to perform only two iteration with each pattern. This was necessary to prevent the "catastrophic interference" among patterns of different frames. To test the performance of the trained ANN approximately 4000 patterns have been extracted from each frame. The 4000 patterns cover the whole image region of a frame and contain normal and suspicious samples.

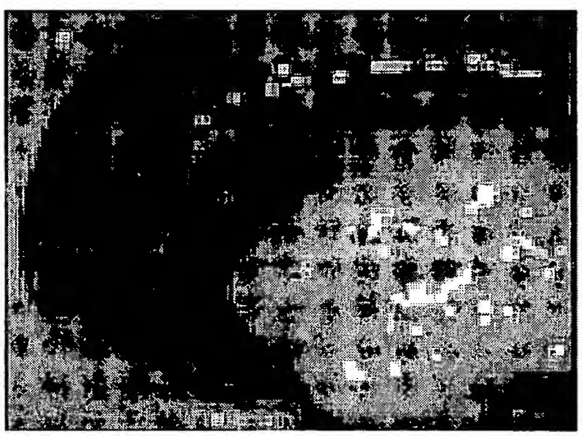

Figure 2: Frame of the colonoscopic video sequence.

The generalization results with and without the evolution stage of the algorithm, are exhibited in Table 1. The first column of Table 1 exhibits results from training a special ANN for each frame and, then, testing it using data from the same frame without on–line retraining. From example, let us observe Frame 1. The corresponding ANN was trained using data extracted from Frame 1 and achieved a recognition success of 83.77% when tested with the whole frame. Similarly, a percentage of success of 87.60% was achieved by the ANN that was trained on Frame 4. On the other hand, the hybrid method by applying on–line retraining managed to locate weights that are eminently suitable for all of the four frames. Thus, the ANN trained with the hybrid method provides higher percentage of generalization in all cases when compared with the four specially trained ANNs.

	Without Evolution	With Evolution
Frame 1	83.77%	91.91%
Frame 2	77.18%	83.57%
Frame 3	82.84%	93.09%
Frame 4	87.60%	89.24%

Table 1: Results from the interpretation of images.

5 Conclusions

A new hybrid method for on–line neural network training has been developed, tested and applied to a texture classification problem and a tumor detection problem in colonoscopic video sequences. Simulation results suggest that the new method exhibits fast and stable learning, good generalization and therefore a great possibility of good performance. The proposed algorithm is able to train large networks on–line, and seems better suited for tasks with large, redundant or slowly time–varying training sets, such as those of image analysis. Further work is needed to optimize the hybrid algorithm performance, as well as to test it on even bigger training sets.

Acknowledgements

The authors gratefully acknowledge the contribution of Dr. S. Karkanis and Mr. D. Iakovidis of the Image Processing Lab at the Department of Informatics and Telecommunications, University of Athens, Greece, in the acquisition of the data.

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Clinical Neurology and Neurosurgery
Volume 99, Supplement 1 , July 1997, Page S101

doi:10.1016/S0303-8467(97)81719-2 Cite or link using doi

Endo-neuro-sonography: A new imaging technique

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Available online 3 March 1999.

Abstract

The step from microneurosurgery to endoneurosurgery does not only mean a step towards minimally invasive technique but also a decrease in safety which leads to reduction of applicability. The goal for further developments must therefore be to make neuroendoscopy a safer technique. One concept is to establish an on-line guiding system which has been tried by MR or CT with an enormous effort of technique and money. A very simple and inexpensive concept is to equip the scope with a sono-guiding system. As this sono-system presents very typical but different anatomical aspects of well known structures, the first step is to present the typical anatomical features of neuro-endosonography.

In 12 specimens the sonographic neuro-anatomical aspects have been worked out and documented by prints, photography and parallel sono- and endoscopy video recording. The

sono-probe with a diameter of 1.9 mm was introduced into the working canal of an endoscope. The sono-pictures are displayed on a monitor parallel to the scope view, on which some parameters can be varied to get the best view of different anatomical structures.

The radial sono view serves like a "mini CT" of 1 cm to 5 cm diameter in which the tip of the probe itself can be seen and guided on-line.

Results of anatomical imaging studies were so convincing that clinical cases have been examined intraoperatively. Preliminary list of indications can already be given: puncture of ventricles, cysts or tumors, examination of aneurysms, intracranial pressure on line monitoring, on line monitoring of pathological processes in ICU patients as substitute for CT, intraoperative endo-neuro-navigation, intraoperative on-line monitoring of tumor resection.

Clinical Neurology and Neurosurgery
Volume 99, Supplement 1 , July 1997, Page S101

VIRTUAL (COMPUTED) ENDOSCOPY:

DEVELOPMENT AND EVALUATION USING THE VISIBLE HUMAN DATASETS

[Presented at the Visible Human Project Conference, October 7-8, 1996,

National Library of Medicine, National Institutes of Health, Bethesda, Maryland]

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Introduction

Virtual endoscopy (or computed endoscopy) is a new method of diagnosis using computer processing of 3-D image datasets (such as CT or MRI scans) to provide simulated visualizations (1,2) of patient specific organs similar or equivalent to those produced by standard endoscopic procedures (3). Conventional CT and MRI scans produce cross section "slices" of the body that are viewed sequentially by radiologists who must imagine or extrapolate from these views what the actual 3 dimensional anatomy should be. By using sophisticated algorithms and high performance computing, these cross sections may be rendered as direct 3-D representations of human anatomy. Specific anatomic data appropriate for realistic endoscopic simulations can be obtained from 3-D MRI digital imaging examinations (4) or 3D acquired spiral CT data (5).

Thousands of endoscopic procedures are performed each year. They are invasive and often uncomfortable for patients. They sometimes have serious side effects such as perforation, infection and hemorrhage. Virtual endoscopic visualization avoids the risks associated with real endoscopy, and when used prior to performing an actual endoscopic exam can minimize procedural difficulties and decrease the rate of morbidity, especially for endoscopists in training. Additionally, there are many body regions not accessible to or compatible with real endoscopy that can be explored with virtual endoscopy. Eventually, when refined, virtual endoscopy may replace many forms of real endoscopy.

The term ***"virtual endoscopy"*** is not quite syntactically correct. Webster's definition of ***"virtual"*** has two main components: 1) "...possessed of certain physical virtues..." and 2) "...being such in effect, though not formally recognized...". The definition of ***"endoscopy"*** is also two-fold: 1) "...visualizing the interior of a hollow organ..." (Webster), and 2) "...visual inspection of any cavity of the body by means of an endoscope..." (Dorland's Medical Dictionary). Thus, the concatenation of the terms ***virtual*** and ***endoscopy*** does not result in a syntactically congruent phrase (e.g., "being such in effect though not formally recognized in visualizing the interior of a hollow organ"). The term ***"virtuality"*** is actually better -- meaning 1) "essence of..." and 2) "potential existence of..." (Webster). This leads to a syntactically and

semantically correct phrase: ***"endoscopic virtuality"***, meaning *"the essence of visualizing the potentially existing interior of an object..."*. This is what is meant in *reality* by the term virtual endoscopy. It conveys the extended power and capability of this technique for looking inside any object, hollow or not, existing or not. Additionally, the resultant visualizations are actually computed images, so the term ***"computed endoscopy"*** is perhaps more accurate and descriptive still (similar to comparing computed tomography with conventional tomography). But the term ***virtual endoscopy*** has been used so prevalently as to probably preclude modification in the common vernacular, so for practical and historic purposes, the term virtual endoscopy will be used in this paper to convey the same meaning as ***endoscopic virtuality***.

Although there has been speculation about virtual endoscopic capabilities since the early 1970's, as dramatized in the science fiction movie *"Fantastic Voyage"*, the recent availability of the Visible Human Datasets (VHD) from the National Library of Medicine (see **Figure 1** and **Figure 2**), coupled with the development of computer algorithms to accurately and rapidly render high resolution images in 3-D and perform fly-throughs instead of inserting long instruments (endoscopes of any kind) into a patient, has provided modern realization of these capabilities. The VHD provides a rich opportunity to help advance this important new methodology from theory to practice.

Table 1 lists some of the real virtues of the Visible Human Datasets. Combined, they constitute a uniqueness and completeness unmatched by any other standardized dataset. Such images are not available routinely in any laboratory or hospital; that is, high 3D resolution (~1 mm) multimodality images of the entire body, both male and female.

Table 1

Some Virtues of the Visible Human Dataset
Whole Body Images
Male and Female
Multimodality (CRYO, CT, MR)
High Resolution Digital Anatomy
Good Isotropic (3-D) Resolution
Available Free of Charge

These combined attributes have resulted in VHD popularity and utilization exceeding the expectations and goals of its conceivers. Facilitated by free availability from the National Library of Medicine, National Institutes of Health (39), it has become an international standard dataset for development and implementation of a wide variety of useful applications.

Advanced approaches to visualization of specific anatomical models in support of endoscopic training, rehearsal, or diagnosis can be implemented on a virtual reality display system (6-8). Such displays are "immersive", and allow the endoscopist to simultaneously visualize

the anatomy and manipulate the viewing orientation in a realistic way (9,10). In fact, virtual endoscopy provides viewing control and options that are not possible with real endoscopy, such as direction and angle of view, scale of view, immediate translocation to new views, lighting, and measurement. Visual feedback positioning systems and navigation guides can orient the virtual endoscopist relative to the actual anatomy. Image values from the original data can be associated with any view and quantitatively assessed. Simulated views can be compared to actual endoscopic images and post-operative pathologic data to validate their usefulness. There are many body regions not accessible to real endoscopy that can be explored with virtual endoscopy. Several important body systems are compatible with invasive probes including the heart, spinal canal, inner ear (cochlea, semicircular canals, etc.), biliary and pancreatic ducts and large blood vessels. These are important anatomic structures ideally suited for virtual endoscopy.

The VHD is being used by an ever increasing number of investigators to develop, test, and compare 3-D visualization and image processing methods, and to evaluate the effectiveness of these methods, including endoscopic simulation, for eventual applications in clinical diagnosis and therapy. These methods include algorithms for registration, segmentation, classification, modeling and rendering, all of which may be used in various forms of computed virtual endoscopy. As 3-D medical imaging and computer power improve, virtual representations of anatomic and physiologic data have become increasingly realistic and interactive, significantly advancing the science of computed non-invasive endoscopic examination. However, there remains a critical need to refine and validate these simulations for routine clinical use, and the VHD is ideally suited for this. Table 2 categorizes into four main groups some useful applications of the VHD.

Table 2

Some *Real* Applications of the Visible Human Datasets

Algorithms	**Education**	**Modeling**	**Prototyping**
rendering	digital anatomy	deformable models	surgery planning
segmentation	reference libraries	physical attributes	anesthesia delivery
registration	knowledge bases	physiological attributes	virtual laparoscopy
classification	biology framework	realistic animations	virtual endoscopy

The Biomedical Imaging Resource at Mayo Clinic was one of the first laboratories to receive (August, 1994) this unique, high resolution image dataset -- the Visible Human Male (VHM) -- and has been actively engaged in developing and evaluating a variety of image processing methods with it. These efforts have included accurate segmentation and modeling of all major anatomical structures of the VHM. More

recently, similar efforts with the Visible Human Female (VHF) have been carried out.

These data and studies have been used to develop and evaluate virtual endoscopic procedures applied to a variety of intraparenchymal regions of the body, using both anatomic modeling and perspective volume rendering, to produce fly-through movie sequences of the stomach, colon, spine, esophagus, airway, heart and aorta of the VHM, and of the sinuses, bronchial tree and female reproductive system of the VHF. **Figure 3** shows a transparent rendering of a torso model of the VHM and several computed endoscopic views. Illustrated in the simulated endoscopic views are different types of navigation guides superimposed upon the display to help the user interactively determine body orientation and precise anatomical localization while performing the virtual endoscopic examination.

The virtual visualizations of the trachea, esophagus and colon have been compared with standard endoscopic views by endoscopists who judge them to be realistic and useful. Especially useful is texture mapping onto the computed virtual intra-parenchymal surfaces of the trachea, esophagus and colon using patient-specific samples from the real endoscopic images of these regions. Quantitative measurements of geometric and densitometric information obtained from the computed virtual endoscopic images ("virtual biopsy") are being carried out and compared with other direct measures on the original VHM and VHF data. Preliminary analyses suggest that virtual endoscopy can provide accurate and reproducible measurements.

We have developed specific clinical protocols to compare virtual endoscopy with real endoscopy and other diagnostic procedures. Preliminary results from these studies are encouraging and will help drive improvements in and lend credibility to virtual endoscopy as a clinical tool. However, there are a number of technical problems that have yet to be solved to make virtual endoscopy a clinical tool with sufficient scientific validity and ease of use to be employed on a routine basis. These will be addressed later in this paper. But rapid progress is being made toward successful solution of all of these problems and toward realization of the significant promise of virtual endoscopy.

Background

The history of virtual endoscopy is a brief one. It is a new technology in diagnostic medical imaging. Virtual endoscopy derives principally from digital medical imaging, and in particular from visualization of 3D CT and MRI datasets. However there are roots in non-medical areas of 3-D visualization, including computer science, terrain guidance, flight path planning and flight simulation (11,12). The fundamental concept common to all of these efforts is the representation of real world objects (in the case of medicine, patient organs and tissues) as spatial information. For digital medical image information, the spectrum of physical and computer science methods available to acquire, process, analyze, convert, scale, enhance, fuse, distribute and transmit information can be applied in ways that permit diagnostic and therapeutic capabilities beyond current human physical abilities and possibilities. This is the promise of the Information Age.

A number of investigators have been working in this field. Some of the earliest work was published by Vining (13,14) on virtual colonoscopy, Lorensen (15) performing 3-D fly-throughs of carotid arteries and A-V malformations, Robb (6,16,17) who began with patient specific 3-D organ visualizations and progressed to interactive organ fly-throughs, Hara and Johnson (18) who have published early clinical observations in the colon, Jolesz and Kikinis (19,20) who developed "enhanced reality" using 3-D visualization and image fusion for stereotactic neurosurgery, and Rubin and Napel and colleagues (2,21) who have applied simulated endoscopy to a variety of intra-parenchymal

visualizations. As 3-D medical imaging and computer power improved, these early pioneers appreciated the power and promise of virtual representations for realistic visualization and manipulation to advance the science of non-invasive endoscopic diagnosis.

Continuing recent work (22-26) characterizing the rapidly maturing development and evaluation of virtual endoscopy in a variety of applications suggest that this technology is "a winner", and will in fact become a routine clinical tool in the near future.

Methods

One general schema for producing virtual endoscopy procedures is diagramed in **Figure 4**. Three-dimensional images are first acquired from a scanner (e.g., spiral CT, MRI, confocal microscopy). Invariably, some preliminary processing on this data is required to properly prepare it for modeling. This "pre-processing" step may include interpolation to transform the dataset into isotropic elements, registration to bring all images into spatial synchrony, and segmentation to reduce the dataset to the desired specific anatomic structure(s). Many approaches to model creation have been proposed (27-33), but generally single anatomic objects must first be segmented from the 3-D images and their surfaces extracted. The isolated surface is then converted to a geometric representation, a process referred to as "tiling", by transforming surface coordinates to a meshwork of polygons. The polygonal surface representation may then have appearance modifying information added to it, such as color, lighting, textural patterns, etc. This processed dataset comprises the model, which then may be rendered for visualization using a surface or volume rendering algorithm, of which there are many available (16,35-37). The user or operator previews the rendering and accepts it as faithful and/or useful, or the user can choose to repeat some phase of the process (e.g., segmentation and/or surface definition) to obtain an acceptable model for rendering. This iteration and "acceptance" decision is generally made by a human expert (e.g., radiologist, surgeon, endoscopist). The endoscopic display procedure is then simulated in one of two ways -- 1) on-line, real-time display using an interactive simulator, such as a virtual reality display system (6,38) with rapid computational capabilities which can produce updated displays at real-time rates in response to user interactions (e.g., using a head-mounted display, head tracking and 3-D input devices); or 2) a pre-determined "flight path" is used to compute sequential frames of views which are rendered in an animated video sequence. There are variants to this overall process, but it is generally representative of current methods for virtual endoscopy.

Another approach to virtual endoscopy is diagramed in **Figure 5**. In this method a model is not generated, but rather the appropriately segmented images are rendered directly using volume rendering with perspective (2,16,36). This is a well-known ray-casting approach (35-37) which generates various surface views using a specified set of conditions and/or constraints on the rendering process as rays are passed mathematically through the voxels of the 3-D image. Perspective volume rendering differs from parallel volume rendering by the direction that the rays are cast. Parallel volume rendering projects all rays in a parallel trajectory through the volume. This is computationally simple, resulting in speed and efficiency. Rays cast in parallel can be considered to originate from an eye position at infinity, and do not converge. Conversely, rays cast in perspective originate at a finite eye position and are cast at divergent angles relative to one another through a projection plane and then into the volume. Parallel renderings are usually acceptable for large data sets with the viewing point outside and arbitrarily removed a far distance from the volume. Virtual endoscopy which places the eye positions in close proximity to visible surfaces requires the casting of rays in a perspective geometry, especially from view points inside the volume. By appropriately modifying the algorithms and parameters used in perspective rendering, the visualizations produced can effectively emulate images captured from actual endoscopic examinations. The shading models available for parallel volume rendering are applicable for perspective volume rendering.

Because virtual endoscopy requires an eye position inside the volume, voxels in close proximity to the eye appear larger than voxels at a distance from the eye. Because the voxel covers many pixels of the resulting visualization, it is in effect super-sampled by the algorithm and can result in a visualization that appears "blocky". By using trilinear interpolation in perspective volume rendering, the display can be effectively smoothed by sub-sampling the data to match the sampling rate of the rays being cast through the volume. Trilinear interpolation increases the computational load of the algorithm by an order of magnitude compared to parallel volume rendering. Current workstations are able to render a perspective image in under 10 seconds from a 256^3 volume.

Since perspective volume rendering is a computationally intense procedure, even the fastest of modern workstations cannot render full visualizations of large images at real-time rates (30 frames per second), although this is a solvable problem with continuing advances in computer technology. Therefore, similar to the off-line option of the modeling approaches, pre-determined flight paths and animation are performed to produce cine sequences that can be viewed subsequently at video frame rates. In contrast to modeling, the potential power of perspective volume rendering, especially when computational rates become less prohibitive for large datasets, is that the intrinsic 3-D richness of the volume data is preserved, including depth layers that may hold subtle but important information to enhance the usefulness of the visualization, such as blood vessels in the luminal wall, fine trabeculations, subdural lesions, etc. Such detail is not likely to be captured in surface models.

The user interface to a virtual endoscopy system varies depending on the display mode. In real-time simulations (6,9-11,19,38) the user wears a head-mounted display or special stereo glasses and manipulates the 3-D image with various feed-back and 3-D input devices. This interface is immersive and responsive on-line, and places the user inside the visualization domain (vis-a-vis *"Fantastic Voyage"*). In cine or video path tracking, the interface is generally a computer workstation screen and pointing device that the user employs outside of the visualization domain to control replay of pre-determined fly-throughs. These displays can also be rendered and replayed on video tape, CD-Roms or other multi-media devices.

Evaluation

Critical to the success of any new method for clinical applications is careful validation. The VHD is playing an important role in this regard. Table 3 depicts this role in the schematic hierarchy of approaches to validation of any new technology or method. Traditionally, mathematical simulations and phantom studies are carried out to help validate a new method, but the performance (accuracy and reproducibility, sensitivity and specificity) of new methods for clinical diagnosis or therapy necessarily includes both *in vitro* and *in vivo* studies as well. The difficulty is not having a "ground truth" measure for validation. The VHD provides this with the cryosection data, against which image processing effects using the CT and MR data can be calibrated and judged. And the ground truth cryosection data itself can be used to produce very realistic simulations for testing procedures. The standardized dataset also provides a basis for multi-center studies and facilitates important end user evaluation (i.e., the physician, surgeon, anatomist, and/or endoscopist).

Table 3

Evaluation and Validation Using the VHD

Simulations
Phantoms
Real Data (VHD)
Cryosections "ground truth"
Multi-Center Comparisons
End User Participation

The visible human male (VHM) dataset from the National Library of Medicine (39) has been used to develop methods for eventual application in clinical diagnosis and therapy. These methods include the algorithms for segmentation, modeling and rendering which are used in virtual endoscopy. Models of the torso and its contents made from the VHM have been used to evaluate several virtual endoscopic procedures, as was illustrated in **Figure 3**.

Figure 6 shows a virtual endoscopy view captured from a fly-through of the segmented and modeled stomach of the VHM. This visualization illustrates the surface detail that can be visualized with virtual endoscopy (the procedure used is similar to that described in **Figure 4**). **Figure 6** also illustrates three different navigation guides superimposed upon the display to help the user interactively determine body orientation and precise anatomical localization while performing the virtual endoscopic examination. The icon at the upper right dynamically updates body position relative to current eye viewing position; the transparent thumbnail of the model at upper left shows a bright dot at the 3-D location of the current view; and the CT section at lower left is perpendicular to the current viewpoint with a bright dot showing the current projected anatomic location of the virtual endoscopic probe.

Figure 7 shows four panels of virtual endoscopy views with navigation guides captured at selected locations during fly-throughs of the VHM trachea (upper left), esophagus (upper right), colon (lower left) and aorta (lower right). The view from mid-trachea shows the first main bi-furcation of the airway; the esophagus view is near the opening of the stomach; and the colon view is from within the sigmoid. The virtual visualizations of the trachea, esophagus and colon have been compared with real endoscopic views by endoscopists who judge them to be realistic and useful.

The view in the lower right panel of **Figure 7** is from within the aorta and shows the junction of the innominate, left common carotid and left subclavian arteries. Such visualizations are not possible with real endoscopy. **Figure 8** further illustrates this advantage of virtual endoscopy, showing the segmented heart model from the VHM and 3 additional endoscopic views within the major vessels and chambers, including the superior vena cava, right ventricle and pulmonary trunk. These different views also demonstrate the capability of virtual endoscopy for rapid translocation of viewpoint. Again, such views are impossible with real endoscopy.

Figure 9 is another visualization of the colon of the VHM, illustrating the model of the descending colon. **Figure 10** shows four different endoscopic views from within the central portion of the descending colon (top) and from within the sigmoid (bottom).

Figure 11 illustrates rendered views from front and back of the skeleton of the VHF. The segmentations were produced by thresholding on the CT data. More refined segmentations using 3-D region growing and math morphology were performed on the skull and brain. **Figure 12** shows transparent renderings of the skull model, including segmented sinus and middle ear passages through which virtual endoscopic fly-throughs can be performed. **Figure 13** is a composite image showing transparent volume renderings of the brain, including two virtual endoscopic views from within the cerebrospinal ventricular system, one looking from the base into the fourth ventricle and the other from within the right lateral ventricle adjacent to the caudate nucleus.

Figure 14 shows models of the trachea segmented from the VHF, including an endoscopic view looking toward the first main bronchial branch. These model surfaces have been texture-mapped with the spatially-congruent pixel values from the digitized cryosection data.

Figure 15 shows a model of segmented pelvic contents of the VHF, showing the hip bones, female reproductive system, and urinary system. **Figure 16** illustrates simulated endoscopic views from within the left and right fallopian tubes, the uterus, and a ureter.

Quantitative measurements of geometric and densitometric information contained in these models and the correlated image data can be carried out. Preliminary studies and analyses (40,45) are providing growing evidence of the potential of virtual endoscopy for accurate and reproducible visualizations.

Some Applications and Problems

One of the useful applications of the VHD models has been to serve as framework for medical education, anesthesiology training, surgery rehearsal and endoscopic simulations. Although the focus of this paper is on virtual endoscopy, it is instructive to illustrate an example of one of these other applications, namely surgery rehearsal, as it relates to virtual endoscopy. **Figure 17** is a posterior oblique view of the pelvic girdle of the VHM with a model of the bladder, prostate gland and other adjoined structures, including a tumor, computed from a patient MRI volume scan and carefully registered and inserted into the VHM pelvis. The VHM pelvic girdle model serves as an anatomic framework for studying the patient-specific models of the prostate. (The pelvic bones are not available on the MRI scans.) The urologic surgeon can use such displays in a real-time virtual environment to critically study the anatomic relationships pre-operatively. Virtual endoscopy can be performed in the bladder, urethra, and prostate gland itself for detailed visualization of locations, shapes and sizes, particularly relative to the tumor and critical structures like the seminal vesicles and neuro-vascular bundles. Segmentation of the VHM pelvis and prostate gland and adjacent anatomy was one of the first "proofs-of-concept" for helpful 3-D visualization of prostate anatomy in patients. **Figure 18** shows a detailed model of the VHM prostate and relative structures, as well as models from two cancer patients. The patient-specific models can be studied independently, within the framework of the VHD pelvic model, or within the patient's own pelvic girdle if it is available from CT scan data (the CT scan data can be accurately registered with the MRI data before producing the visualization (6,17)). Virtual endoscopy can be performed on these patient specific models to precisely visualize the interior of the prostate and embedded tumor relative to critical anatomic structures, such as the urinary sphincter, seminal vesicles and neuro-vascular bundles, helping to define appropriate surgical margins in order to reduce the risk of post-operative complications (such as incontinence or impotence).

Although virtual endoscopy is in the embryonic evaluation stages in clinical practice, descriptions of methods and preliminary results are increasing in scientific meetings, workshops and publications (2,6,13,15,17,18,40-47). Reported here are two typical clinical examples of virtual endoscopy -- one in esophageal cancer and one in colon cancer -- which have been made possible using methods first developed and tested on the VHD.

Figure 19 illustrates a sequence of image processing steps in preparation for a virtual endoscopy exam of the esophagus. The upper left panel in **Figure 19** shows four cross-sections through the chest from a spiral CT scan of an esophageal cancer patient. The cancer, which constricts and almost completely occludes the esophagus, can be seen in Section number 3. The upper right panel is a transparent volume rendering of several segmented anatomic structures from this scan, including the skin, lungs, trachea, esophagus, cancer and part of the stomach. The location of the selected cross-sections are indicated by the dashed lines. The lower two panels illustrate renderings with some objects removed. In the lower right panel, the esophagus is seen to be "squeezed off" by the circumferential constricting cancer, making it impossible to segment the distal portion adjoining the stomach.

Figure 20 illustrates four virtual endoscopy views of this patient's esophagus, computed from the segmented esophagus shown in **Figure 19**. The upper left panel shows a segment of normal esophagus near level 1. The upper right panel is a view from just above the pronounced narrowing in the esophagus near level 2. The lower left panel is yet a more distal view just above level 3 which reveals an infiltrating portion of the cancer (red). The lower right panel is the same view as the lower left, but the esophageal wall has been rendered transparent to reveal the entire lesion wrapped around the esophagus. Such global views of the cancer are impossible with real endoscopy.

Figure 21 illustrates volume renderings of segmented anatomic structures from a spiral CT scan of a patient with colon cancer and polyps. The upper left image is a transparent rendering of a portion of the large bowel selected for segmentation and the rather large circumferential rectal cancer at its distal extent. The upper right and lower left images reveal these same anatomic segmentations at different angles of view with the skin removed. The lower right panel shows a volume rendering of the isolated large colon and cancer from a posterior oblique view. Also identified, segmented and rendered in this image is a polyp (blue) in the mid-sigmoid region.

Figure 22 shows different ways of digitally analyzing the patient polyp with virtual endoscopy. The upper left panel is a texture-mapped virtual endoscopic view of the polyp at close range, and the upper right panel shows an enhancement of the polyp against the luminal wall. Such enhancement is possible only with virtual endoscopy, since the polyp itself can be digitally segmented and processed (e.g., brightened) as a separate object. The lower left panel is a transparent rendering of the polyp, revealing a dense interior region which was also segmented. This is most likely a denser-than-normal vascular bed, perhaps a pre-cursor of malignancy. The lower right panel illustrates the capability for "virtual biopsy". Both geometric and densitometric measures may be obtained numerically from the segmented polyp (density measures can be computed from the original image data).

A **Short Video** sequence illustrating a virtual endoscopic fly-through of the rectal and sigmoidal portions of the patient colon is included with this manuscript. The movie demonstrates dynamic updating of on-screen navigation guides for anatomic orientation and location. Near the end of the sequence a 180 degree turn-around is performed to move back toward the polyp shown in **Figure 22**. This maneuver is not possible with real endoscopy.

The visual fidelity of current generation virtual endoscopy images is not yet at the level of diagnostic accuracy suitable for regular clinical use. There are a number of technical problems that have to be solved to make virtual endoscopy a clinical tool with sufficient scientific validity and ease of use to be employed on a routine basis. These include: 1) 3-D image resolution, 2) accurate surface rendering, 3) automatic segmentation, 4) robust registration and 5) appropriate preparation.

Current 3-D images from CT and MRI scans readily demonstrate resolving power to 5 mm, and some laboratory results on phantoms are demonstrating images of lesions with 1 and 2 mm accuracy (39-42). The current generation of helical or spiral CT scanners are capable of 1 mm resolution (5), but this is not used routinely. As scanner resolution improves to the submillimeter level, the resolution of virtual endoscopy will also improve. Current scanning resolution can be used for screening procedures of clinically relevant lesions in the colon, but improvements to at least the 1 mm level are required to support a broad spectrum of use.

Higher 3-D resolution will provide the requisite structural and anatomical detail for clinical use of virtual endoscopy; however surface textures comparable to those in the optical image obtained from standard endoscopy still require significant improvement. Surface rendering uses a variety of shading techniques and/or application of generic texture mappings related to the specific organ (27,31); therefore surface (e.g. mucosal) details in such renderings are only a form of mimicry. Since these are not patient specific, they are not helpful for diagnostic purposes. Diagnoses based upon anatomic deformities by mass lesions (polyp, cancer, cyst, edema from inflammation, ulcer, stricture, etc.) can be made, but other lesions which are diagnosed by subtle mucosal changes (inflammation, superficial ulcers, vascular ectasia, etc.) cannot be faithfully represented by current virtual endoscopy methods, since the requisite information is not captured in the CT or MR scan.

Achieving accurate, reproducible and hopefully automatic organ or tissue segmentation remains a significant challenge. Segmentation is an essential step to permit individual organs to be distinguished from one another. Currently, segmentation is most often done by "post production" techniques -- after the full image data set is acquired, the data is either meticulously segmented manually (drawn or identified by hand) or by various semi-automatic algorithms. Some promising progress toward fully automated 3-D segmentations of both hard (bone) and soft (skin, muscles, etc.) tissue is being realized (17,48). What is ultimately desirable is for the image to be automatically segmented "on the fly" as it is being acquired, and then be immediately usable as the fully segmented organ with or without a series of cross sectional or multiple orthogonal views. Until this occurs, capabilities for routine visualization of 3-D image datasets as virtual organs and tissue will be available at only a few centers with sufficient resources to effectively process the images.

Like segmentation, solutions to the problem of automatic, frameless registration between two or more images is needed for routine clinical implementation of these visualization methods. Currently, fiducial markers are required for proper acquisition and alignment (fusion) of images from different imaging sources such as CT or MRI, or from video and CT. While this can be routinely accomplished with static images, the application to dynamic images as obtained during surgery is limited to a few selected applications, such as stereotactic neurosurgery. In order to extend the utilization to a broader field of procedures, robust solutions will need to be developed for on-line dynamic acquisition (49) and fusion of in vivo organs and tissues which change in shape and position.

Some organs or tissues require special preparation in order to be properly visualized. Gastrointestinal structures such as the colon need to be "prepped" with various regimes to remove feces that interfere with segmentation and interpretation. Under most circumstances, blood vessels

require injections of contrast material to enhance their contrast for visualization using medical imaging scanners. While some traditional preparatory methods might be effective, other newer techniques will be needed to provide a level of visualization adequate for routine clinical implementation.

Summary

There is a broad range of potential applications of the Visible Human and Specific Patient datasets, of which virtual endoscopy is an integral part. For example, once the image data is acquired and "virtualized", it can be used for diagnosis as a virtual gross anatomic (or pathologic) specimen or as a virtual endoscopy model used for pre-operative planning of a specific complicated surgical (or radio therapy) procedure, practiced upon as a surgical (or catheter based or radio therapy) procedure simulator, and in certain cases used as a prognostic planner. In order to help understand the current state of the art relative to what appears to be a useful clinical goal for a virtual patient, Table 4 classifies the evolutionary types or generations of medical procedure simulation using virtual environments for applications based on all levels of gross, microscopic and physiologic representation.

Table 4

Taxonomy for Several Generations of Virtual Anatomy

Generation	**Properties**	**Example**
1	Geometric anatomy	3-D organ shapes
2	Physical dynamics modeling	Kinematics, deformations
3	Physiologic characteristics	Bleeding, leaking bile
4	Microscopic anatomy	Neurovascular, glandular
5	Biochemical systems	Endocrine, immune, shock

Each succeeding generation is more complex, integrates the preceding generation, and follows a chronological development based upon technical limitations of the time period. The ultimate goal is to produce a virtual photo-realistic human that has complete physical, physiologic and systemic fidelity. Initially 3-D geometric anatomic shapes were computed, with some simple interactivity (generation 1). This permitted identification of gross anatomic structures, simple fly-throughs, and very crude manipulation of cartoon-like organs, such as gall

bladder, liver, etc. Computer power rapidly increased to usher in generation 2, which had more realistic graphics, included physical properties of tissue, such as stretching and deformation (plasticity), and allowed interactive positioning of anatomic structures. Interactive simulations could be performed (deform, cut, divide, etc.) on any portion of the virtual organ. There are a few virtual representations that are beginning to incorporate generation 3, which includes physiologic properties such as breathing, bleeding, leaking of bile or urine, motility, etc. in highly realistic renderings. Generation 3 has utilized either the Visible Human or patient specific data derived from CT, MRI and other imaging modalities. These comparatively high resolution actual data sets have significantly increased the realism, visual fidelity and clinical usefulness because the virtual representations are based upon real human anatomy, not upon graphic drawings or approximations.

One new application in "spatial physiology" developed in the Biomedical Imaging Resource at Mayo Clinic could be considered the one of the first examples of generation 4. The purpose of generation 4 is to add microscopic level detail to the anatomy, rendering with high fidelity miniature size structures such as neurovascular bundles, glandular structures within mucosal surfaces, and even individual cells. In **Figure 23** a 3-D model (left) of a single neuron from the inferior mesenteric ganglia of the gastro-intestinal system obtained from a confocal microscope scan is shown, along with four virtual endoscopy views (right) of this extraordinary model captured from a fly-through of the neuron. The views include a close up of the surface and three views from "inside" the neuron. The location of somal junctions for several dendrites can be seen, and one view (lower right) projects into a single dendritic appendage. Images of such miniature structures, including the ganglia and individual cells obtained from microscopes can be accurately placed within the anatomy of the Visible Human, as shown in **Figure 24**, to provide a global framework and context for study of the microstructures. **Figure 25** illustrates another "celluloscopic" fly-through of a single mesenteric neuron, but one for which receptor sites for specific neuro-transmitters have been determined and mapped onto the model surface. These receptor sites can be seen at specific locations from within the body of the cell. This type of fourth generation synthesis of micro, histo and gross anatomy demonstrates the potential for a seamless integration of human anatomy and spatial physiologic function from macroscopic to microscopic levels.

The fifth generation in the taxonomy of virtual anatomy will include complex biochemical parameters with multi-organ system integration to represent systemic functions, such as neuro-endocrine and immunologic functions or pathologic states such as shock. As the 4^{th} and 5^{th} and perhaps successive generations are realized, the virtual representation continues to become more realistic, and hence useful. A virtual endoscopic procedure on this level of image representation might eventually become indistinguishable from the actual patient and permit a continuous, seamless fly-through from gross anatomic, through endoscopic and finally to microscopic realms.

Virtual endoscopy is the fountain head of an entire generation of new diagnostic opportunities. Theoretically, most if not all internal structures can be visualized using this modality (i.e., "endoscopic virtuality"). The clinical benefits are *a priori*, though clinical validation will be needed. No longer will the patient require a sedative, insertion of an instrument into a natural body opening or minimally invasive opening, hospitalization or ambulatory center observation following the procedure, all of which increases the risk of complications and/or adds cost to the procedure. Early success will be in those organ systems of large size that have no intrinsic motion and which maintain a lumen without special assistance or preparation. This includes but is not limited to the tracheo-bronchial tree, renal system from calyces to bladder, pancreatico-biliary tree, uterus, cerebro-ventricular system, spinal canal and major joints. Areas that require special attention include the upper GI tract (requires insufflation), colon (requires bowel prep), vascular tree (requires contrast material) temporal bone and inner ear (requires higher resolution) and heart (requires motion accommodation/correction). In addition to the benefits for non-invasive diagnosis, the

potential exists for use of virtual endoscopy in combination with non-invasive energy directed therapeutics, such as high-intensity focused ultrasound. And the surface has only been scratched in the areas of education, training, and treatment planning (48,50). Virtual endoscopy epitomizes a first realization of the remarkable promise of modern imaging and computing technologies. A real fantastic voyage into the *inner sanctum* of the human body has been launched with the aid of the Visible Human Datasets.

Acknowledgments

The author is grateful to his colleagues in the Biomedical Imaging Resource at Mayo Clinic who provide technical assistance in producing the software described and visualizations illustrated in this manuscript. Clinical image data was generously provided by Dr. Michael Vannier and Dr. Charlene Prather. The neuron data was provided by Dr. Joseph Szurszewski. The author also acknowledges the use of the Visible Human Male and Female Datasets from the National Library of Medicine. Special thanks are extended to Darlene Bernard for preparation of the manuscript. Portions of this paper are reproduced from a manuscript accepted for publication in PRESENCE, by permission of its authors, R. Satava and R. Robb.

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International Congress Series
Volume 1230, June 2001, Pages 210-217
Computer Assisted Radiology and Surgery

doi:10.1016/S0531-5131(01)00038-3 Cite or link using doi

Virtual reality surgical training and assessment system

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Available online 3 February 2003.

Abstract

This paper presents a description and analysis of the different issues that must be addressed in order to successfully simulate a surgical environment and to obtain reliable measures of surgical skills. It then explores possible solutions to extend the current limits of realism by using today's technology. The proposed techniques are demonstrated on a first prototype system implementing the basic algorithms.

Author Keywords: Virtual reality; Computer graphics; Simulation; Real-time systems;

Physical modelling; Deformable tissue modelling; Surgical skills assessment

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International Congress Series
Volume 1230 , June 2001, Pages 210-217
Computer Assisted Radiology and Surgery

Image and Vision Computing
Volume 18, Issue 10 , July 2000, Pages 795-804

doi:10.1016/S0262-8856(99)00047-5 Cite or link using doi

Real time tracking of borescope tip pose

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Received 30 January 1998; revised 12 April 1999; accepted 17 September 1999. Available online 3 May 2000.

Abstract

In this paper we present a technique for tracking borescope tip pose in real-time. While borescopes are used regularly to inspect machinery for wear or damage, knowing the exact location of a borescope is difficult due to its flexibility. We present a technique for incremental borescope pose determination consisting of off-line feature extraction and on-line pose determination. The off-line feature extraction precomputes from a CAD model of the object the features visible in a selected set of views. These cover the region over which the borescope should travel. The on-line pose determination starts from a current pose estimate, determines the visible model features, and projects them into a two-dimensional image coordinate system. It then matches each to the current borescope video image (without

explicitly extracting features from this image), and uses the differences between the predicted and matched feature positions in a least squares technique to iteratively refine the pose estimate. Our approach supports the mixed use of both matched feature positions and errors along the gradient within the pose determination. It handles radial lens distortions inherent in borescopes and executes at video frame rates regardless of CAD model size. The complete algorithm provides a continual indication of borescope tip pose.

Author Keywords: Pose estimation; Borescope inspection; Idustrial inspection; Lens distorsion

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Image and Vision Computing
Volume 18, Issue 10 , July 2000, Pages 795-804

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Set     Items   Description
S1    1272970   METHOD?
S2    7392076   SYSTEM?
S3    1388554   PROCEDURE?
S4    4306331   PROCESS?
S5      29710   VIDEOSCOP? OR BRONCOSCOP? OR BRONCHOSCOP? OR BRONCHISCOP? -
             OR ENDOSCOP? OR FLEXIBLE()(TOOL? OR INSTRUMENT? OR CYLINDER?)
S6          0   DC=(E7.230.220? OR E7.858.240?)
S7    1139982   INSTRUCTION? OR DIRECTION? OR NAVIGATION?
S8     164623   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
             CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
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             N? OR PATH? OR GEOMETR? OR MAP OR MAPPING OR MAPS)
S9      46591   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
             CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
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             MAGING OR ORIENTATION? OR CONFIGURATION? OR TRAJECT?)
S10     13230   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
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             TOMOGRAPH? OR MRI OR ULTRASO? OR MAGNETIC?()RESONAN?)
S11       814   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
             CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
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             NSION? OR 2()DIMENSION? OR TWODIMENS? OR TWO()DIMENSION?)
S12      5754   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
             CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
             PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(3()D OR 3DIME-
             NS? OR 3()DIMENS? OR THREEDIMEN? OR THREE()DIMEN?)
S13     41745   TBNA OR TRANSBRON?()NEEDLE?()ASPIRAT? OR BIOPS?
S14    659918   CHARACTERISTIC? OR PARAMETER? OR ROTATION?
S15   1455175   DIAMETER? OR LENGTH? OR DISTANCE? OR DEPTH?
S16    476505   BEND? OR DEFLECT? OR CURV? OR ANGLE? ?
S17     34335   (ANATOM? OR BODY OR BODILY)(2N)(LANDMARK? OR SITE? OR TARG-
             ET? OR STRUCTURE? OR PART?) OR CARINA?
S18    187772   LESION? OR TUMOR? OR TUMOUR? OR TRACHEOBRONC?()TREE?
S19    890061   GUIDE? ? OR GUIDING OR MANIPULAT?
S20   8640397   HANDLE? ? OR HANDLING OR INSERT? OR OPERAT?
S21     23966   S1:S4 AND S5:S6
S22      3899   S21 AND S7:S12 AND S14:S18
S23       950   S22 AND S1:S4(5N)S19:S20
S24       188   S23 AND S19:S20(5N)S5:S6
S25        21   S24 AND S7:S12(5N)S14:S18
S26        73   S24 AND S13
S27        81   S25 OR S26
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29/5,K/2 (Item 1 from file: 148)
DIALOG(R)File 148:Gale Group Trade & Industry DB

13101045 SUPPLIER NUMBER: 70396527 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Minimally Invasive and Robotic Surgery.
Mack, Michael J.
JAMA, The Journal of the American Medical Association, 285, 5, 568
Feb 7, 2001
ISSN: 0098-7484 LANGUAGE: English RECORD TYPE: Fulltext; Abstract
WORD COUNT: 3213 LINE COUNT: 00342

ABSTRACT: Advances in video imaging, instrumentation, and **endoscopes** have made minimally invasive surgery a possibility. The use of robots and miniaturized instruments will revolutionize surgery even more.

DESCRIPTORS: Surgery--Research; Laparoscopic surgery--Research
FILE SEGMENT: MI File 47

ABSTRACT: Advances in video imaging, instrumentation, and **endoscopes** have made minimally invasive surgery a possibility. The use of robots and miniaturized instruments will...

TEXT:

Advances in surgery have focused on minimizing the invasiveness of surgical **procedures** , such that a significant paradigm shift has occurred for some **procedures** in which surgeons no longer directly touch or see the structures on which they **operate** . Advancements in video imaging, **endoscope** technology, and instrumentation have made it possible to convert many **procedures** in many surgical specialties from open surgeries to **endoscopic** ones. The use of computers and robotics promises to facilitate complex **endoscopic** **procedures** by virtue of voice control over the networked operating room, enhancement of dexterity to facilitate...

...diagnostic and therapeutic modalities through natural orifices in which investigation is under remote control and **navigation** , so that truly "noninvasive" surgery will be a reality.
... century, and especially during the last decade, there has been a paradigm shift in the **methods** for performance of surgery. For many **procedures** , the "invasiveness" involved has been dramatically reduced resulting in superior outcomes manifested as improved survival...

...been the subject of intense investigation in recent years.

Developments in Minimally Invasive Surgery

The **methodological** innovations in surgery are only beginning. For the first time, it is possible for surgeons...

...frequently due to trauma involved in gaining access to the area to perform the intended **procedure** rather than from the **procedure** itself. For example, following a cholecystectomy, the need for hospitalization was not related to the...

...sources that improved visualization of the surgical field, and (3) improved hand instrumentation designed for **endoscopic** approaches. For the first time, the surgeon did not look directly at the target structure...

...and illumination.

Within a few years gallbladder surgery changed from an open

technique to an **endoscopic** **procedure** (TABLE). Laparoscopic techniques were then applied to other **procedures** in the abdominal cavity, including hernia repair, (4) esophageal reflex surgery, (5) and colon surgery. (6) Applications include pelviscopy in gynecology, blebectomy and lung **biopsy** in thoracic surgery, (7) and cardiac surgery. (8,9) However, the enthusiasm and momentum initiated by laparoscopic cholecystectomy (lapcholy), led to unrealistic expectations of early conversion of other surgical **procedures** to less invasive approaches. The immediate and overwhelming success of this one **procedure** was not repeated with other **procedures** .

Surgical **procedures** can be categorized based on complexity and can be divided into either excisional, in which...

...is removed (eg, appendectomy, cholecystectomy); ablative, in which tissue is destroyed (eg, cryosurgery of hepatic **tumors**); or reconstructive, in which structures are joined or connected (eg, bowel or Fallopian tube anastomosis, coronary artery bypass grafting). Excisional or ablative **procedures** are easier to perform than reconstructive **procedures** and are more easily adaptable to **endoscopic** techniques.

Surgical **procedures** also can be categorized as either high volume or low volume. High-volume **procedures** are more successful in a shorter period of time than low-volume **procedures** because of the opportunity to learn the **procedure** more quickly and because of the "market opportunity" presented for technology development. The success of the lapcholy was in large part due to the simple excisional **procedure** , the opportunity (400 000 **procedures** per year) for surgeons to perfect the approach, and for the medical device industry to invest in development. Other excisional **procedures** have not been as quick to convert because of lower case volumes. Neither have other high-volume **procedures** , such as coronary artery bypass grafting, been as rapidly converted to an **endoscopic** approach because of the complexity and reconstructive nature of the surgical **procedure** .

Minimally Invasive Cardiac Surgery

Although cardiac surgery has been performed successfully more than 10 million...

...access to the heart contributed to significant morbidity. Cardiac surgery is different than other surgical **procedures** because the heart-lung machine adds further morbidity. Although coronary artery bypass graft surgery was...

...attempted to make cardiac surgery less invasive. The MIDCAB (minimally invasive direct coronary artery bypass) **procedure** involved a single vessel bypass on the anterior surface of the heart on a beating heart through a small anterior thoracotomy. (12) The Port Access approach attempted totally **endoscopic** coronary artery bypass surgery on an arrested heart still using cardiopulmonary bypass. (13) Because of the complexities involved with cardiac surgery, the totally **endoscopic** approach was prohibitive and both mitral valve and simple coronary bypass **procedures** were performed through a small thoracotomy incision.

Although these initial developments catalyzed the minimally invasive movement in cardiac surgery, they now constitute a minority of cardiac surgery **procedures** . However, they did evolve to the current OPCAB (off pump coronary artery bypass grafting) **procedure** in which multivessel bypass is performed on a beating heart through a median sternotomy incision. Although wide exposure is still presented and the surgeon performs the **procedure** under direct vision with conventional instruments, elimination of the heart-lung machine and performance of the **procedure** on a beating heart improves outcomes. This approach is less invasive than conventional cardiac bypass surgery. (14,15) The success of these **procedures** is facilitated by mechanical stabilizers, that provide local

immobilization and stabilization of the coronary artery...

...evolving but now is used in approximately 18% to 20% of all coronary artery bypass **procedures** in the United States (Hospital Corporation of America hospital **system** case-mix database, 1999).

Complex Minimally Invasive Surgical **Procedures**

The application of the minimally invasive **procedure** to more complex surgeries will require the new technology and techniques. In general surgery, techniques such as hand-assisted laparoscopy attempt to bridge the gap between open and completely **endoscopic** **procedures** . Other possibilities include developing new ways to perform conventional surgical tasks as a way to adapt these **procedures** to an **endoscopic** or less invasive approach. Examples include using implantable devices to treat gastro-esophageal reflex disease...

...sutures and staples by biological glues and sealants.

Much effort is being expended to improve **endoscopic** coronary bypass surgery. (16) To facilitate a totally **endoscopic** approach on a beating heart, there is an intense interest in the use of facilitated...

...battlefield, space station, or developing country) was thought to expand surgical application. Although simple surgical **procedures** have been performed remotely, there is no clear path to practical application at present because...

...minimally invasive surgery. Potential tasks facilitated by computers and robotics include information gathering and networking, **navigation** and guidance, (18) dexterity enhancement, (19) and simulation of virtual environments. The goal is to create a completely integrated **system** that converts information to action. The ideal would be to transcend human limitations by information...

...of the body difficult to access.

Current applications of robotics include surgical assistance, dexterity enhancement, **systems** networking and image- **guided** therapy. Dexterity is enhanced by placing a microprocessor between the surgeon's hand and the...

...enhancement of robotic assistance. (20)

Another focus on dexterity enhancement is in laparoscopic surgery and **endoscopic** coronary artery bypass surgery using surgical robotic **systems** (FIGURE). (21,22) **Endoscopic** coronary bypass **procedures** performed on a beating heart have been performed although enhancements and further technique development are...

...illusion of stillness by "gating" or timing the instrumentation and scope with the heart beat.

Endoscopic approaches involve special challenges. First, loss of degrees of freedom are lost by the limitation...

...lost on a 2-dimensional television screen, and potential solutions to current 2-dimensional imaging **systems** include digital enhancement, shadowing to create the illusion of 3 dimensions, and high resolution image display. Three-dimensional imaging has been limited by the loss of resolution associated with filtering **systems** and by the size of the visualization **system** necessary to produce **depth** perception. These challenges are being addressed by some current and soon to be available **systems** .

Potential use of nonvisual imaging techniques, including 3-dimensional modeling and reconstruction of imaging data from computerized tomography, magnetic resonance imaging, and ultrasound, provide real-time data acquisition of pathological **characteristics** and to assess delivery

of percutaneous therapy remotely. Other possible roles for computer and robotic...

...exists to give the surgeon voice control over virtually all operating room equipment including electrocautery, **operating** table position, **endoscopic manipulation**, lighting, and telephone. Future developments promise the overlay of additional data to the operative field...

...acquisition.

Conclusion

Advancements in the last 10 years made it possible to perform a surgical **procedure** without directly visualizing or touching the organ being operated on. Efforts are now focused on...

...complex tasks by minimally invasive approaches. Technologies that will impact surgery include those that allow **procedures** to be performed through natural orifices, such as treatments for esophageal reflex disease ...radiation) under image guidance (eg, magnetic resonance imaging and ultrasound) will permit the ablation of **tumors** of the prostate, breast, liver, and lung without the need for an incision. Noninvasive approaches... ...allow the development of swallowable cameras, implantable sensors and medical records, microrobots for completing surgical **procedures**, and magnetically controlled implants that can be navigated remotely. The technology is here, the potential...

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Surgical **Procedures** Performed by a
Minimally Invasive Approach, 1999 (*)

No. of **Procedures**

Minimally Invasive, % (+)

General surgery		
Gallbladder	1 084 882	85
Nissen fundoplication	47 087	95
Adhesiolysis...		

...15

Face and forehead lifts	80 000	25
Total	262 000	18
Thoracic surgery		
Lung **biopsy**	90 000	75
Lung resection	47 124	60
Total	160 000	60
Cardiothoracic surgery		

Coronary...Development and Forecast:
Robotics and Computer Assistance in Surgery

Task	Function
Surgical Assistant	Voice-Activated **Endoscopic** Holder/Positioner
Dexterity Enhancement	Facilitate Precision **Endoscopic** **Procedures**
Motion Scaling	
Tremor Filtration	
Force Feedback	
Operating Room **Systems**	Surgeon Control of or Via Voice
Networking	Activation, Touch Screen
Telepresence Surgery	Surgeon at Remote...

...Site

Information Enhancement	Real-Time Data Acquisition
3-Dimensional Modeling and Reconstruction	and Nonvisual Imaging
Image Referencing Guidance	
Virtual Stillness (Motion Stabilization)	"Gate" Time Visualization and Surgical Instruments to Heart Motion to Create Illusion...

...Information Enhancement Action in Response to

Sensory Feedback	Nonvisual Feedback
Microelectronic Mechanical **Systems**	Miniature Autonomous Robots

Task	Forecast
Surgical Assistant	Becoming Routine
Dexterity Enhancement	Of 1000 **Procedures** Now
Motion Scaling	Performed, 50% Are Cardiac
Tremor Filtration	and 50% Are Laparoscopic
Force Feedback	
Operating Room **Systems**	Rapid Integration of **Operating**
Networking	Room **Systems** in Near Future
Telepresence Surgery	No Clear Path to Clinical
Remote Surgery	Application
Telementoring	Demonstrated...

...Image Referencing Guidance and Ultrasonography With Surgical Overlays to Facilitate Percutaneous Therapy

Virtual Stillness (Motion Stabilization)	Facilitate **Endoscopic** "Beating Heart" Surgery
Virtual Simulators	About to Become Realistic and Affordable

Information Enhancement...

...Delivery of

	Drug/Energy Based on Tissue-Level Feedback
Microelectronic Mechanical **Systems**	Remote Diagnosis and Delivery Via Body Lumina

20010207

29/5,K/19 (Item 2 from file: 444)
DIALOG(R)File 444:New England Journal of Med.

00109275

Medical Progress: Gastrointestinal Endoscopy **(Second of Two Parts) (Review Article)**

Morrissey, John F.; Reichelderfer, Mark.
The New England Journal of Medicine
Oct 24, **1991** ; 325 (17),pp 1214-1222
LINE COUNT: 00523 WORD COUNT: 07227
ISSN: 0028-4793
CORPORATE SOURCE: From the Department of Medicine, University of Wisconsin Medical School, 600 Highland Ave., Madison, WI 53792, where reprint requests should be addressed to Dr. Morrissey.

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* * USE FORMAT 9 FOR FULL TEXT OF ARTICLE * *

Medical Progress: Gastrointestinal Endoscopy **(Second of Two Parts) (Review Article)**

1991 ;

TEXT

...Fibersigmoidoscopy

Although many indications for fibersigmoidoscopy are listed in Table 2, the majority of **procedures** are surveys for cancer in asymptomatic persons. Although the American Cancer Society (Ref. 123) and...

...over 40 at three-to-five-year intervals, not all authorities are convinced that the **procedure** is cost effective (Ref. 125,126). All studies have found a substantial number of polyps...

...patients with adenomatous polyps of the colon could be identified through fibersigmoidoscopy and then a **biopsy** of any polyps that were found, since rectosigmoid adenomas were thought to be present in...

...No symptomatic cancers developed despite a projected incidence of from 11.8 to 37.3 **tumors** . This study was the first to show that colonoscopic polypectomy almost surely reduces mortality from...
...it provides strong support for the use of colonoscopy rather than fibersigmoidoscopy as the screening **procedure** of choice. Unfortunately, this alternative is prohibitively expensive at present. A compromise might be to...

...that this may be the case, since tubular adenomas less than 1.0 cm in **diameter** were not associated with an increased risk of more serious **lesions** in the proximal colon, such as larger polyps, villous adenomas, or cancers, unless the patient...

...and nearly all hyperplastic polyps found on sigmoidoscopy are less than 1.0 cm in **diameter** .

...

...Hematochezia is the next most common indication for fibersigmoidoscopy. This **procedure** is most effective in making a diagnosis in ...majority of these patients within a few days, and special studies are not required. The **endoscopic** appearance and **biopsy** findings in such patients are nonspecific, except in immunocompromised patients, who may have viral infections...

...Colonoscopy

Colonoscopy is a difficult, time-consuming **procedure** that can be hazardous and quite uncomfortable. Concern about competence has led both the American Society for Gastrointestinal **Endoscopy** (Ref. 5) and the American College of Physicians (Ref. 8) to publish guidelines. There is good evidence that the **procedure** is overused, based on data from insurance carriers identifying **endoscopists** who perform both upper gastrointestinal **endoscopy** and colonoscopy on the same day in a high percentage of their patients...

...indications for colonoscopy (Table 3), although it accounted for 35 percent of referrals for the **procedure** in a recent survey (Ref. 140). Colonic pain can be due to an obstruction, which...

...have documented greater diagnostic success with colonoscopy in such

patients. The American Society for Gastrointestinal **Endoscopy** (Ref. 143) and the American College of Physicians (Ref. 8) recommend colonoscopy as the initial...

...cost of colonoscopy is more than 1.34 times the total cost of the other **procedures** ; they recommended colonoscopy for all patients over 55 years old with occult blood in the...
...studies were not needed in asymptomatic patients (Ref. 145).
Colonic Polyps
Colonoscopy is a reliable **method** of diagnosing colonic polyps of 1.0 cm or more, as shown by a study...

...in that study, colonoscopy is still much more accurate than barium enema in identifying small **lesions** . It is the accepted practice to remove all polyps found on colonoscopy (Fig. 5). Polyps less than 5 mm in **diameter** need not be retrieved for **pathological** examination in **patients** who have had previous neoplastic polyps, since the risk of malignancy in these small **lesions** is only 0.01 percent (Ref. 147,148). Once adenomas are found, examinations are appropriate... **Endoscopists** have been successful in providing palliation for patients with inoperable colon cancer using the neodymium...

...group was able to ameliorate symptoms in 75 percent of the patients with inoperable rectosigmoid **tumors** (Ref. 155). This group also used the laser to destroy villous adenomas in the same...

...however, colonoscopy is the best test because of its high accuracy and therapeutic potential. Many **endoscopists** have **lengthened** the intervals between screening colonoscopies to reduce costs and because studies suggest that it may...

...universal ulcerative colitis for at least eight years is one of the most common surveillance **procedures** . A long-term study in Sweden found that the ratio of observed to expected colon...the creation of a W pouch because the functional results are excellent and because the **procedure** eliminates both the need for future colonoscopies and the risk of missing a curable carcinoma...

... **Endoscopic** Retrograde Cholangiopancreatography
Biliary Tract Disease
In a **patient** with jaundice, **ultrasonography** is usually the first diagnostic study performed after clinical evaluation and routine laboratory studies (Ref...

...If the biliary tree appears normal and the clinical picture is consistent with hepatocellular disease, **endoscopic** cholangiography is not indicated. If the bile ducts are dilated or the analysis of blood chemistry suggests cholestasis, the choice is between transhepatic and **endoscopic** cholangiography. Intravenous cholangiography has been abandoned in most centers because of its poor clinical efficacy. Most studies have shown a lower rate of complications with **endoscopic** cholangiography (1 to 3 percent) (Ref. 176) than with transhepatic cholangiography (5 to 15 percent) (Ref. 177). With the advent of **endoscopic** therapy for biliary stones and strictures, and the improved success rate of the **endoscopic** approach with increased experience and better instruments, the balance has swung heavily toward **endoscopic** cholangiography as the **procedure** of choice (Table 4). *Table 4. Indications for **Endoscopic** Retrograde Cholangiopancreatography *. **TABLE OMITTED...

... **Endoscopic** cholangiography has recently been shown to be useful in

evaluating a number of rare causes...

...sclerosing cholangitis (Ref. 181).

Abdominal Pain

Patients with unexplained abdominal pain are frequently referred for **endoscopic** cholangiopancreatography. The efficacy of such **procedures** is poor unless there is laboratory or radiographic evidence of biliopancreatic disease (Ref. 9,182). In fact, unless such abnormalities are present, many authorities would argue that the **procedure** is not indicated (Ref. 9...

...sphincter is present) (Ref. 184,185). Although there are favorable reports of the use of **endoscopic** or surgical sphincterotomy in such cases, (Ref. 186,187) any such treatment remains controversial, particularly when the sphincter is cut despite normal laboratory and radiographic findings. A few **endoscopists** use manometry to detect abnormally high pressure in the area of the sphincter and believe...

...can relieve pain by sphincterotomy in such cases (Ref. 186). Manometry remains a technically difficult **procedure** , however, and is not without substantial risk of pancreatitis (Ref. 184,188).

Pancreatic Disease

Endoscopic cholangiopancreatography is of considerable value in patients with acute pancreatitis when gallstones are suspected as...

...common-duct stones often produces dramatic improvement in patients who meet these criteria, and the **procedure** will treat coexisting septic cholangitis as well (Ref. 189). Cholangiopancreatography is also indicated in patients...

...finding common-duct stones. Other potentially treatable conditions include choledochocele, ampullary obstruction by stenosis or **tumor** , pancreatic pseudocyst or a surgically approachable ductal pathologic condition, and pancreas divisum, which is a...Ref. 193) with ductal dilatation or the demonstration of delayed drainage suggesting the need for **endoscopic** or surgical drainage (Ref. 188...

... **Endoscopic** pancreatography is not the best initial screening **procedure** for chronic pancreatitis, because CT and other imaging studies are effective, less invasive, and less...

...the mechanism of pain may be related to gland and nerve involvement in the inflammatory **process** rather than to ductal obstruction, and the condition may not be amenable to surgical therapy (Ref. 192,198). **Endoscopically** placed stents are being developed for the treatment of painful chronic pancreatitis, pancreatic pseudocysts and...

... **Endoscopic** pancreatography has played a smaller part in the diagnosis of carcinoma of the pancreas since the advent of CT scanning with directed needle **biopsy** . Pancreatography has been helpful in patients with equivocal study results and should become even more...

...or pancreatic duct (Ref. 202).

Common-Duct Stones

One of the most compelling indications for **endoscopic** cholangiography is the presence of common-bile-duct stones. **Endoscopic** sphincterotomy provides effective therapy in most cases (Ref. 203,204). To avoid complications such as...

...with that involved in surgical exploration of the common duct, and the recovery from uncomplicated **endoscopic** **procedures** takes hours rather than days or weeks. Initial concern about long-term complications of sphincterotomy...

...Techniques for dealing with difficult stones include the use of crushing baskets, **endoscopic** laser lithotripsy, (Ref. 208) stone dissolution, (Ref. 209) and extracorporeal shock-wave lithotripsy (Ref. 210...

...duct stones and an intact gallbladder, many high-risk patients have common-duct stones removed **endoscopically** with no further treatment of the gallbladder unless symptoms develop (Ref. 212,213). Perhaps dissolution ...

...infusion of dissolving agents into the gallbladder), with or without lithotripsy beforehand, will routinely accompany **endoscopic** sphincterotomy in high-risk patients (Ref. 214-217...

...who require cholecystectomy (Ref. 218). In patients with acute suppurative cholangitis, however, establishing biliary drainage **endoscopically** before surgery is a way to avoid emergency surgery and thus improve the ultimate outcome...Prophylactic changing of the stent may decrease the incidence of this complication but requires repeated **procedures** . For these reasons, **endoscopic** stenting is reserved for patients with malignant obstructions or high-risk patients with benign obstructions...

...Stents cannot be placed **endoscopically** in all obstructing **lesions** , particularly when the strictures involve the hepatic ducts. Such **lesions** can be stented transhepatically in most cases (Ref. 177). Percutaneous stenting had a higher rate...

...and mortality in one randomized trial, however, (Ref. 184,227) and patients who undergo the **procedure** are left with a percutaneous drainage tube, which can be painful. In some cases, a...

...difficult problem, with the radiologist passing a wire percutaneously through the strictured area and the **endoscopist** using the wire as a **guide** to push a stent through the stricture (Ref. 177,228,229...

...In most studies, **endoscopic** stenting of malignant strictures is as successful as surgical bypass, is cheaper, and causes less discomfort, despite the need to replace the stents (Ref. 230-232). **Endoscopy** may not provide a tissue diagnosis, however, and only surgery offers the opportunity for a...

...has not improved survival in most randomized trials, (Ref. 233-235) although trials involving the **endoscopic** techniques currently in use have not yet been reported, and establishing nasobiliary drainage or placing...

...Ref. 236). Sclerosing cholangitis with major ductal strictures may also respond at least temporarily to **endoscopic** therapy, (Ref. 181) although the long-term results are unknown and there have been no...

... **Endoscopic** Ultrasonography

Ultrasonic **endoscopes** are now available for examining the upper digestive tract (Table 5) (Ref. 237-239). The equipment is quite expensive, costing over $100,000, and whether the information provided by this **method** will make it cost effective remains to be seen. There is an obvious advantage to...

...structure being visualized, thus avoiding interference from bone or gas. *Table 5. Indications for Ultrasonic **Endoscopy** *. **TABLE OMITTED...

...There are two **systems** in use. The **endoscope** -mounted **system** uses a dedicated fiberscope fitted with a rotating mechanical sector scanner at its tip. Contact...

...by filling the stomach with water or using a water-filled balloon attached to the **endoscope** . The main disadvantage of the instrument is that it is a poor **endoscope** and must be passed separately, after a **lesion** has been seen with a standard **endoscope** . The second **system** involves a thin ultrasonic probe that is passed through the **operating** channel of a standard **endoscope** (Ref. 240...

...The **systems** use frequencies of from 7.5 to 20 MHz. The higher the frequency the greater the resolution, but the shallower the **depth** of penetration. The high-frequency **system** permits visualization of the individual layers of the mucosa and is suitable for studying submucosal **lesions** (Ref. 241,242) and detecting the **depth** of invasion of **tumors** , such as rectal (Ref. 243) and esophageal (Ref. 239) cancers. The lower frequencies are used...

...to the gastrointestinal tract, such as the pancreas, (Ref. 244) and the bile ducts. Pancreatic **tumors** less than 2.0 cm in **diameter** have been visualized when they could not be seen by other techniques (Ref. 244). The ...been replaced by a light-sensitive computer chip mounted directly on the tip of the **endoscope** that transfers the image electronically. The chip is a charge-coupled device with a large...

...wheel in the control unit that alternately flashes red, green, and blue light through the **endoscope** at 20 to 30 frames per second. Resolution is excellent with both **systems** and is superior to that obtained by a television camera attached to a standard fiberscope (Ref. 247). Research is in progress to take advantage of the capacity of **videoscopes** to image nonvisible wavelengths, such as infrared radiation...

...Approximately 70 percent of the **endoscopes** sold this year will be videoendoscopes, because they have several advantages over conventional fiberscopes (Ref. 248). They are less fatiguing for the **operator** during long **procedures** , such as colonoscopy. The **biopsy** channel is farther from the **endoscopist** 's face, thereby reducing the risk of contact with secretions. Everyone in the room, or...

...other cities, can see the image. Of greater importance, they increase the effectiveness of the **endoscopic** assistant. The principal disadvantage is that the presence of blood impairs the image. Unfortunately, the...

...chips that are quite expensive, so there is no cost saving in the purchase of **videoscopes** .

...

...Videoendoscopic **systems** produce an analogue image that can easily be converted to a digital image for storage...

...improve documentation and communication. In the future, routine hard-copy documentation will be mandatory in **endoscopy** , as static-film documentation has become necessary in radiology...

...are indebted to Michael Mitchell of the Olympus Corporation of America for several of the **endoscopic** photographs.

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29/5,K/21 (Item 1 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

02013853 SUPPLIER NUMBER: 76994078 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Thoracoscopy or CT-Guided Biopsy **for Residual Intrathoracic Masses After Treatment of Lymphoma(*).**
Gossot, Dominique; Girard, Philippe; de Kerviler, Eric; Brice, Pauline; Rain, Jean-Didier; Leblanc, Thierry; Grunenwald, Dominique
Chest, 120, 1, 289
July,
2001
PUBLICATION FORMAT: Magazine/Journal; Refereed ISSN: 0012-3692
LANGUAGE: English RECORD TYPE: Fulltext TARGET AUDIENCE: Professional
WORD COUNT: 3707 LINE COUNT: 00313

DESCRIPTORS: Hodgkin's disease--Imaging; Non-Hodgkin's lymphomas--Imaging; Thoracoscopy--Evaluation
FILE SEGMENT: HI File 149

Thoracoscopy or CT-Guided Biopsy **for Residual Intrathoracic Masses After Treatment of Lymphoma(*)....**

TEXT:

...Gallium scan and positron emission tomography allow for diagnosis in most cases. However, in some **patients** , a **pathologic** examination of the residual mass (RM) is required. The aim of this study was to evaluate the results of a thoracoscopic approach for intrathoracic RM, as compared with image-guided **biopsies** .

Patients and **methods** : From 1996 to 1998, 29 consecutive patients treated for NLH (n = 11) or HD (n...

...either to radiology (group R; n = 8) or to surgery (group S; n = 21) for **biopsy** of an intrathoracic RM. There were 13 male and 16 female patients ranging in age from 15 to 56 years (mean, 32 years). The reason for a **biopsy** was the inability to determine the nature of the RM by means of radiologic examination or scintigraphy. **Biopsy** was defined as successful when (1) residual lymphoma was found in the specimen, or (2...

...the patient remained disease-free after a minimal follow-up period of 12 months. A **biopsy** was defined as a failure when a local recurrence occurred in a patient with a diagnosis of benign **lesion** .

Results: No significant **procedure** -related complications occurred in either group. The mean follow-up was 26 months (range, 13...
...0.5). In the seven patients of group R with a diagnosis of benign mediastinal **lesion** , two patients had a local recurrence and one had a recurrence within the abdomen. In...

...in this series, results suggest that a thoracoscopic approach yields better data than image-guided **biopsies** . (CHEST 2001; 120:289-294)

Key words: Hodgkin's disease; gallium scan; lymphoma; mediastinum; residual...

...receive long-term therapy and follow-up, physicians are usually reluctant to use an invasive **method** to achieve diagnosis. Among noninvasive **methods** are CT, MRI, gallium citrate Ga67 scan (GS),(1-3) thallium scan,(4) and positron...

...lymphomas. Thus, some patients are still referred to the radiologist(7) or the surgeon for **biopsy** .(8) The aim of this work was to assess the role of surgical **endoscopic** and image- **guided** techniques in the diagnosis of intrathoracic RM.

MATERIALS AND **METHODS**

From 1996 to 1998, 29 patients treated for NLH (n = 11) or HD (n = 18) have been referred to radiology (group R) or surgery (group S) for **biopsy** of an intrathoracic RM (Table 1). There were 13 male and 16 female patients ranging...

...2

Pleural effusion	0	1

(*) Data are presented as No.

Nineteen patients underwent GS before **biopsy** ; 6 patients were in group R and 13 patients were in group S. Results of GS are listed in Table 2. The reason for a **biopsy** was the inability to determine the nature of the RM by means of radiologic examination or scintigraphy.

Group R

Eight **patients** underwent a **CT** -guided **biopsy** of a mediastinal RM (group R). There were neither pulmonary nor pleural **lesions** in this group. A coagulation screen was performed in all patients, and informed consent was obtained prior to the **procedure** . In teenagers, informed consent was obtained from parents. The **biopsy** **procedure** was performed on an outpatient basis in all cases.

Biopsies were performed by two experienced radiologists from our staff. CT scanning was used for **biopsy** guidance. After disinfecting and sterilely draping the patient's skin, a local anesthesia was performed with a 1% lidocaine solution. The puncture was performed by using standard coaxial percutaneous **biopsy** technique in all cases using a semiautomated **biopsy** gun (Quick-Core **biopsy** needle; Cook; Bloomington, IN) that allows one to obtain a 17-mm-long core of...

...largest masses, we used a sextant technique that consists of tilting the needle in several **directions** in order to obtain tissue samples in different areas. Limited scanning was performed to localize the **lesion** and to document needle progression in **depth** to the target. A 16-gauge **biopsy** needle was used in six patients, and an 18-gauge needle was used in two patients, making two to six passes (mean, 3.6 passes). **Biopsies** were fixed in a solution of acetic acid, ethyl alcohol, and formol. When

malignant lymphoma was diagnosed on **biopsy** specimen, a panel of antibodies was used to determine cell lineage and histologic subtype.

Group three to four ports were needed for a rigid 10-mm thoracoscope and **endoscopic** instruments. Two patients had a history of previous conventional surgical **biopsy** (one sternotomy and one thoracotomy) that led to intraoperative difficulties.

In the case of a...

...a hook wire combined with methylene blue labeling under CT-scan guidance was the preferred **method** for localizing the nodule.(11) When a large **tumor** was present, a large partial **biopsy** was performed using scissors and **endoscopic** suturing. When the nodule was small, it was fully resected using a regular wedge resection with an **endoscopic** stapler. In the case of a mediastinal **tumor** , multiple **biopsies** were performed at different levels to minimize the hazard of overlooking residual cells.

A chest...

...failure criteria due to the lack of complete pathologic proof. We chose to assert a **biopsy** as successful in the two following instances: (1) residual lymphoma was found in the specimen...

...of 12 months. Similar criteria are usually chosen when dealing with this issue.(12) A **biopsy** was defined as a failure when a local recurrence occurred in a patient with a diagnosis of benign **lesion** .

RESULTS

In group R (n = 8), residual lymphoma was found in only one patient. Fibrosis...

...Sarcoidosis	0	1
Normal mediastinal fat	0	2

(*) Data are presented as No. Two different **lesions** may coexist in the same patient.

In group S (n = 21), residual lymphoma was found...

...patients. Other rare diagnoses are listed in Table 2. In group S, two patients underwent **biopsy** of both a pulmonary nodule and a mediastinal mass. In one of these patients, residual...

...mediastinum and tuberculosis was found in the lung nodule. Another patient had a loculated mediastinal **lesion** (Fig 1). Fibrosis was found in the upper part of the **lesion** and residual HD in the lower part. There was no morbidity in this group. The...

...OMITTED)

Outcome

In the seven patients of group R with a diagnosis of benign mediastinal **lesion** , two patients had a local recurrence and one had recurrence within the abdomen. In the...

...related to a previous sternotomy.

Table 3--Outcomes of Patients Without Residual Lymphoma Found at **Biopsy** (*)

Outcomes	Group R (n = 7)	Group S (n = 14)
Remission	3	11
Recurrence within the **biopsy** site	2	1

Recurrence outside the **biopsy** site 2 2

(*) Data are presented as No.
Correlation With GS
In group R, four...

...GS findings. Two of the three patients with a positive GS and negative CT-guided **biopsy** results had recurrence. The third patient did not have recurrence but was treated on the...

...better in group S than in group R.
Table 4--Correlation Between GS and Final **Pathologic** Result(*)

Result of **Preoperative** GS	Group R (n = 6)	Group S (n = 13)
Positive	4 (fibrosis (n = 3),	6...

...that the patient is disease free. A second-look surgery has been advocated as the **method** of choice by some authors.(14,15) This attitude is questionable for the following reasons: (1) complete removal of **tumoral** and fibrotic tissues requires large incisions in patients who may have undergone previous surgery, (2of mediastinal RMs lead to relapse.(16)

Thus, the use of noninvasive **methods** such as CT, GS, or PET scan seems preferable. However, there is no consensus about the **method** of choice. CT alone does not allow one to discriminate between residual **tumor** and fibrosis or necrosis. According to most recent studies, CT has a poor sensitivity with...

...In a retrospective review of HD and NHL, Stumpe et al(12) have found the **specificity** of **CT** to be only 41% for HD and 67% for NHL. MRI has been shown(17...

...to the end of chemotherapy to avoid false-negative findings. Partially necrotic or small-sized **tumors** may also lead to false-negative findings in GS.

(ILLUSTRATION OMITTED)

PET seems to reach...

...12) have found CT and PET to have similar sensitivities but PET is significantly more **specific** than **CT** . Its **specificity** for RM is 96% in patients with HD and 100% in patients with NHL. However...

...remains and where a pathologic proof is required. Due to the minimal invasiveness, CT-guided **biopsies** are often considered as the **method** of choice when no peripheral palpable lymph node can be **biopsied** . The accuracy of CT-guided **biopsies** for the diagnosis of lymphoma ranges from 80 to 90% in many series,(23-25...

...23) the size of the samples were sufficient for phenotyping in all cases. The CT- **guided** approach has become our **method** of choice for initial diagnosis of NHL and HD. However, our data underline its limitations when dealing with RM. In RM, performing multiple **biopsies** is essential since residual disease usually coexists with fibrotic and/or necrotic tissue or thymic hyperplasia (Fig 3).(26) The fact than two of the seven **CT** -guided **biopsy** **patients** with negative results did have recurrences within the chest indicates that residual cells were most...

...On the other hand, in the surgical group, only 1 of 14 patients with negative **biopsy** results had a local relapse. Furthermore, in this patient, a previous history of sternotomy made...

...GS and PET scan, there are still cases where certainty is wanted, ie, where a **biopsy** is required. Although our results are not significant because of the limited number of patients, our data show that CT-guided **biopsies** do not determine definitely the nature of a RM after treatment of HD or NHL. Only surgery allows for multiple **biopsies** in different sites (as demonstrated in this series, benign and malignant **lesions** may coexist), thus avoiding the risk of missing remaining malignant tissue. In these patients submitted...

...surgery should be avoided for the following reasons: (1) satisfactory specimens can be obtained by **endoscopic** surgical techniques, and (2) open surgery makes an eventual secondary thoracoscopy more difficult and less...
1499-1506
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(26) Gossot D...
20010701

29/5,K/24 (Item 4 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01979520 SUPPLIER NUMBER: 71128131 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Diagnosing Sarcoidosis Using Endosonography-Guided Fine-Needle Aspiration(*).
Fritscher-Ravens, Annette; Sriram, Parupudi V. J.; Topalidis, Theodoros; Hauber, Hans P.; Meyer, Andreas; Soehendra, Nib; Pforte, Almuth
Chest, 118, 4, 928
Oct,
2000
PUBLICATION FORMAT: Magazine/Journal; Refereed ISSN: 0012-3692
LANGUAGE: English RECORD TYPE: Fulltext TARGET AUDIENCE: Professional
WORD COUNT: 4523 LINE COUNT: 00493

DESCRIPTORS: Sarcoidosis--Diagnosis; **Biopsy** , Needle--Diagnostic use;
Mediastinum-- **Biopsy** , Needle
GEOGRAPHIC CODES/NAMES: 4EUGE Germany
FILE SEGMENT: HI File 149

TEXT:

Study objectives: The ability to diagnose sarcoidosis cytologically has been reported previously, but the **method** is rarely used. **Endoscopic** ultrasonography (EUS) is a sensitive technique for detecting mediastinal lymph nodes, which in addition provides...

Patients and **methods** : Nineteen patients with suspected sarcoidosis were investigated using EUS-FNA with a linear echoendoscope and...

...were 94% and 100%, respectively.

Conclusions: EUS of mediastinal lymph nodes in sarcoidosis reveals certain **characteristic** features. However, it is not capable of differentiating the **lesions** from tuberculosis or malignancy. EUS-FNA is a safe and sensitive **method** of aspirating material for cytology and mycobacterial cultures. We believe it will provide a useful alternative in the diagnosis of sarcoidosis.

(CHEST 2000; 118:928-935)

Key words: **biopsy** ; cytology; endosonography; mediastinum; sarcoidosis

Abbreviations: ACE = angiotensin-converting enzyme; ATS = American Thoracic Society; EUS = **endoscopic** ultrasonography; FNA = fine-needle aspiration; TBLB = transbronchial lung **biopsy**

Endoscopic ultrasonography (EUS) was initially used as a **method** of staging GI malignancies,(1) and more recently in the diagnosis and staging of lung...

...to CT imaging of the mediastinum, as it allows assessment of the echo structure in **lesions** (is less than) 1 cm in **diameter** ,(5) and provides an opportunity to obtain material from mediastinal lymph nodes using EUS-guided...

...trachea. With a high-resolution ultrasound transducer, it is possible to detect even very small **lesions** (3 to 4 mm). Studies of EUS-FNA have reported a specificity and positive predictive...

...decisions are necessary, or if alternative diagnoses such as malignant lymphoma, mediastinal involvement of solid **tumors** , or tuberculosis need to be excluded. This generally requires transbronchial **biopsy** or mediastinoscopy. We evaluated the feasibility of using EUS-guided FNA for cytodiagnosis of sarcoidosis.

MATERIALS AND **METHODS**

Nineteen patients (12 men, 7 women; mean age, 55 years; range, 22 to 72 years...

...Table 1), lymphocytosis, an elevated CD4/CD8 ratio in BAL (patients 2 and 4), or **bronchoscopic** **biopsy** specimen showing noncaseating granulomas (patient 1). Patients with undiagnosed mediastinal lymph nodes and a compatible...

...I disease in 12 patients, stage II in 5 patients, and stage III in 2 **patients** . **CT** scanning demonstrated enlarged mediastinal lymph nodes in all patients, and the locations were described according to the American Thoracic Society (ATS) mapping of mediastinal lymphadenopathy.(13) **Bronchoscopy** with BAL was carried out in 18 patients. In seven patients, BAL showed lymphocytosis combined...

...mediastinal lymph nodes, all of these patients would have had to undergo a "blind" transbronchial **biopsy** , CT-guided FNA, or mediastinoscopy. We have reported earlier on the feasibility and safety of using EUS-guided FNA for cytodiagnosis of mediastinal **lesions** ,(4,14) and we used this technique to establish the diagnosis in the present study.

Table 1--Clinical, Laboratory, and **Imaging** **Characteristics** in **Patients** With a Prior History of Cancer and a Suspicion of Sarcoidosis(*)

Patient No./	Clinical	ACE...and
	multiple 1 cm	
5/64/M	Mass in left hilum	

Patient No./ Age/Sex	**Bronchoscopy**
1/48/F	Normal mucosa; histology, NECG; BAL, normal cell differentiation; CD4/CD8, 3.4...

...Histology was obtained by microbiopsy specimen taken using EUS-FNA.

Table 2--Clinical, Laboratory, and **Imaging** Features of **Patients** Without a Prior History of Cancer and a Suspicion of Sarcoidosis(*)

Patient No...	Clinical	ACE,
...Weight loss, weakness		45
13/26/F	Parotiditis	35
14/31/M	Erythema nodosum	47

Patient No./Age/Sex	**CT**
1/34/F	Mediastinal mass suspect for NHL; multiple foci in both lungs
2/54...	
...LNs	
14/31/M	Granulomatous disease in both lungs; bihilar LNs

Patient No./Age/Sex	**Bronchoscopy**
1/34/F	Granulomatous mucosal inflammation; histology, inflammation; BAL: lymphoeytosis; CD4/CD8: 9.7; TB...

26/F	3	NECG	Sarcoidosis Histology: parotis
14/31/M	3	NECG	Sarcoidosis Histology: muscle **biopsy**

(*) NHL = non-Hodgkin's lymphoma; see Table 1 for abbreviations.
((dagger)) Normal range, 8 to...

...up.

EUS evaluation of the mediastinum was performed using an

echoendoscope with an electronic multielement **curved** linear-array ultrasound transducer (Pentax 34 UX; Pentax Ltd; Hamburg, Germany; or Olympus GF UC...

...GIP Medizintechnik; Grassau, Germany) was advanced through the wall of the esophagus into the target **lesions** , and material was aspirated using a 10-mL syringe. Two or three punctures were needed...

...level 7), and in the para-aortal region (level 8), which were not seen on **CT** . However, in five **patients** , nodes located on **CT** pretracheally (level 2), in the left paratracheal area (level 4L), and paracavally could not be...

...EUS-Guided FNA

Two or three EUS-guided FNAs were carried out in a target **lesion** (Fig 2). The number of punctures was based on the macroscopic appearance of cellularity in...

...nodes, the decision on which one to carry out a puncture depends largely on the **operator** 's judgment. This **procedure** is similar to the approach used in lymph node sampling for histology in mediastinoscopy or...In the seventh patient, who had a suspected lung cancer relapse, specimens from an additional **biopsy** via mediastinoscopy and thoracoscopy confirmed sarcoidosis. Corticosteroid therapy was begun in five patients with pulmonary...

...FNA of the lymph nodes in these patients, compared to our general experience with this **procedure** in other mediastinal **lesions** , was an excess amount of blood in the aspirates, particularly in those in whom atypical...

...a history of cancer, when alternative diagnoses such as malignant lymphoma, mediastinal involvement of solid **tumors** , or any kind of metastasis need to be excluded. To avoid missing an opportunity when...

...intrathoracic sarcoidosis using epithelioid cell granulomas in 441 patients, based on cytologic examinations of transbronchial **biopsy** specimens from mediastinal lymph nodes. The results were confirmed histologically using transbronchial lung **biopsy** (TBLB) or thoracoscopy. The sensitivity of cytology was 92%. Cytologic evaluation of material obtained from transbronchial **biopsies** led to a diagnosis of intrathoracic sarcoidosis in 143 of 158 patients. The diagnosis was confirmed in 102 cases by histology via mediastinoscopy, thoracoscopy, or open **biopsy** ? Tambouret et al(23) analyzed the use of FNA in the clinical examination of 32...

...and the diaguosis was confirmed on histology and during the clinical follow-up.

At present, **bronchoscopy** with BAL, TBLB, and/or mediastinoscopy are the standard diagnostic **procedures** for sarcoidosis. BAL is helpful in the diagnosis, as it can determine the lymphocyte subpopulation...

...from 40 to 90%,(11,26) but the rate increases logarithmically with the number of **biopsies** performed per patient.(27) Using TBLB in 42 patients, Mitchell et al(26) demonstrated epithelioid...

...in the lung in 88% of the patients, establishing the diagnosis of sarcoidosis. However, this **procedure** is associated with a significant rate of major complications, such as pulmonary hemorrhage (0.6...

...there is a suspicion of sarcoidosis.(30-32).In a meta-analysis of 16,895

procedures , the reported major complication rates at experienced centers varied between 1.4% and 2.3...

...have been observed in several series of EUS-FNA examinations in the mediastinum, and the **procedure** can be performed on an outpatient basis.(2-4,6-8,14) The sensitivity and specificity rates reported in studies of EUS-FNA in the lymph nodes in combination with **lesions** in the lung have been 89 to 96% and 100%, respectively.(2-4,6,14...some studies. Mishra et al(33) recently reported seven cases of sarcoidosis in 108 EUS-**guided** mediastinal FNA **procedures** . Williams et al(8) diagnosed sarcoidosis in five men by aspirating granulomatous material from bulky...

...with a cytopathologist who is well trained in the cytodiagnosis of sarcoidosis, we extended this **method** to confirm the diagnosis of suspected sarcoidosis. The typical EUS morphology observed in sarcoidosis represents...

...atypical vessels show excess blood in the aspirates, confirming the highly vascular nature of these **lesions** .

This first prospective study of the diagnostic value of EUS-FNA in sarcoidosis shows specificity and sensitivity rates of 94% and 100%, respectively. Sarcoid-like **lesions** were observed in association with lung, breast, colon, and other cancers, which may occur in...

...In those with a history of cancer, however, it remains a theoretical possibility, although such **lesions** have not been described previously in association with cancer of the urinary bladder, endometrium, or cervix, or with melanoma.

To conclude, EUS-FNA is a safe alternative **procedure** for establishing a cytologic diagnosis of sarcoidosis. Before it can be recommended as a routine diagnostic **procedure** in suspected sarcoidosis, however, a study comparing it with standard **procedures** such as TBLB and/or mediastinoscopy will be needed to further define the potential role ...

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...DESCRIPTORS: **Biopsy** , Needle...
... **Biopsy** , Needle
20001001

29/5,K/27 (Item 7 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01968061 SUPPLIER NUMBER: 69964930 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Transbronchial Needle Aspiration **(*) Guidance With CT Fluoroscopy.**
White, Charles S.; Weiner, Eric A.; Patel, Pavni; Britt, E. James
Chest, 118, 6, 1630
Dec,
2000
PUBLICATION FORMAT: Magazine/Journal; Refereed ISSN: 0012-3692
LANGUAGE: English RECORD TYPE: Fulltext TARGET AUDIENCE: Professional
WORD COUNT: 5131 LINE COUNT: 00453

DESCRIPTORS: **Biopsy** , Needle--Evaluation; Lung cancer--Diagnosis; Lungs--**Biopsy**
FILE SEGMENT: HI File 149

Transbronchial Needle Aspiration **(*) Guidance With CT Fluoroscopy.**

TEXT:

Background: **Bronchoscopy** with **transbronchial needle aspiration** (**TBNA**) is valuable to diagnose **lesions** in the mediastinum and lung, but conventional fluoroscopic guidance may be suboptimal. We describe the use of CT fluoroscopy to provide real-time, transaxial **TBNA** localization, thus facilitating **biopsy** .

Methods : Patients were selected because of prior unsuccessful **bronchoscopy** or anticipated difficulty owing to small size or inaccessibility of the **lesion** . CT fluoroscopy consists of a spiral CT scanner adapted using a rapid-reconstruction algorithm and hardware that permits real-time in-room imaging. The **bronchoscope** was **inserted** on the CT scanner, which was used to guide **TBNA** instruments into the target **lesion** .

Results: Of 27 patients who underwent **TBNA** with CT fluoroscopic assistance, 15 had mediastinal nodes, and 12 had lung nodules or focal infiltrates. Mean **lesion** size was 1.7 cm in the mediastinum, 2.2 cm in the lung. A correct diagnosis was established in 10 of 12 mediastinal **lesions** (83%) for which follow-up was available and in 8 lung **lesions** (67%). Diagnoses included small cell and non-small cell lung cancer and invasive aspergillosis. False-negative results were caused by sampling errors or inability to reach the **lesion** as documented by CT fluoroscopy. Postprocedure CT fluoroscopy revealed no complications.

Conclusion: CT fluoroscopy provides effective, real-time guidance for **TBNA** and may be particularly valuable in patients with small or less accessible mediastinal or lung **lesions** .

(CHEST 2000; 118:1630-1638)

Key words: **bronchoscopy** ; CT scan; lung cancer; pulmonary infection; **transbronchial needle aspiration**

Abbreviation: **TBNA** = **transbronchial needle aspiration**

Bronchoscopy with **transbronchial needle aspiration** (**TBNA**) is a minimally invasive alternative to surgical **procedures** for the diagnosis of **lesions** in the mediastinum and lung.(1-5) The **procedure** was developed initially to diagnose disease beyond the visible airway. The location of the abnormality...

...the preprocedure CT scan with landmarks in the airway. Fluoroscopy is occasionally used to guide **TBNA** . However, fluoroscopy is limited by a two-dimensional display format that produces overlap of structures, potentially hindering **biopsy** of either mediastinal or lung **lesions** .

CT scanning has been proposed as a useful guidance technique to

provide a cross-sectional view of the relevant anatomy during the **bronchoscopic procedure** .(6) With earlier CT technology, the slow CT reconstruction times that accompanied each adjustment of the **bronchoscope** limited the practical value of this approach. However, newer CT software enables continuous imaging, also called CT fluoroscopy, to be performed, permitting rapid and precise localization of the **bronchoscopic** tip and needle.(7) We report the use of CT fluoroscopy to assist **TBNA** in a series of patients with mediastinal and lung **lesions** .

MATERIALS AND **METHODS**

Twenty-seven **TBNA procedures** were performed using CT fluoroscopic guidance between November 1996 and September 1999. The patient population ...

...age of 58 years (age range, 28 to 82 years). Seven patients had undergone prior **bronchoscopic procedures** without CT assistance with indeterminate results.

Patients referred for **CT - guided bronchoscopy** were typically selected because they had small **lesions** or had nodules or masses that the pulmonologist judged were not readily accessible to the **bronchoscope** using standard **anatomic landmarks** or fluoroscopic guidance. Availability of the scanner also influenced the decision of whether to use **CT** fluoroscopic guidance. **Patients** who underwent **CT** fluoroscopy-guided **TBNA** were prepared by anesthetizing the airway with 4% lidocaine by inhalation in the **bronchoscopic** suite and the patient was transported to the CT suite. After IV administration of 1 mg atropine and 100 (micro)g fentanyl, the **bronchoscope** was **inserted** intranasally with the patient lying supine on the CT fluoroscopic unit (Xpress/SX Aspire CI/CT; Toshiba Medical **Systems** ; Tokyo, Japan).

The CT fluoroscopic unit consists of a third-generation CT scanner with slip ring technology (spiral capability) that has been adapted with a high-speed array **processor** to permit an increase in speed of reconstruction. An initial 360 (degrees) of raw data is collected and **processed** in 1 s, after which an image is displayed. With each subsequent 60 (degrees) of...

...replay the image sequence and reset the machine for further fluoroscopic imaging runs.

For most **procedures** , the patient was placed feet first into the scanner, with the **bronchoscopist** to the right of the CT table and the **bronchoscopic** monitor and technologist on the left side of the CT table. The radiologist operating the...

...of the CT table such that it was visible to either the radiologist or the **bronchoscopist** with a turn of the head (Fig 1). All personnel who remained in the room...

...CT scan was used to provide a first-order approximation of where to position the **bronchoscope** . Once the **bronchoscope** was advanced to this point (at or immediately below the **carina**), a CT fluoroscopic sequence was obtained to correlate the location of the **bronchoscopic** tip with the target **lesion** . Based on experience and best estimate, the **bronchoscopist** advanced the **bronchoscope** to the area of the target **lesion** . For mediastinal **lesions** , an image set was obtained to confirm a position adjacent to the **lesion** , after which a **biopsy** needle (MR-319, MR-122-1; Mill-Rose Laboratories; Mentor, OH) was **inserted** through the **bronchoscope** and implanted in the bronchial wall. The site of implantation was imaged by CT fluoroscopy to ascertain whether the needle was directed properly toward the site of **biopsy** . Adjustments were made using CT fluoroscopic assistance to assure appropriate **direction** , and the needle

was advanced into the **lesion** . For peripheral **lesions** , a **biopsy** needle or brush (MR 522-1, NB-120; Mill-Rose Laboratories) was passed through the **bronchoscope** into a major airway. Using experience and best judgment, the instrument was directed into a...

...with CT fluoroscopic sequences.

In both mediastinum and lung, CT fluoroscopy permitted confirmation of the **biopsy** site and guided repositioning if several passes were necessary. After the needle was withdrawn, CT...

...obtained to document complications.

For each patient, all available charts and images were reviewed, and **lesion** size and location in the mediastinum or lung were recorded. For ovoid **lesions** , the average of two perpendicular dimensions, with one being the longest axial dimension, was designated as the **lesion** size. The **length** of time from start to end of CT scanning and the amount of fluoroscopic imaging used were documented. Final **bronchoscopic** results were confirmed using the hospital pathology database. The results of subsequent **procedures** or imaging studies were identified through the hospital information **system** , radiology information **system** , and medical record.

RESULTS

Of 27 **procedures** in which CT fluoroscopy was used to assist **TBNA** , 15 targeted primarily mediasfinal or hilar lymph nodes or masses, and 12 were directed toward abnormalities in the lung. All patients underwent TRNA. In two patients, transbronchial **biopsy** was performed with a forceps.

Mediastinal or Hilar **Lesions**

Among mediastinal or hilar **lesions** , the site of the largest, most accessible node that underwent **biopsy** was subcarinal in five patients, hilar in four patients (right hilum, two patients; left hilum...

...2.9 cm. A mean of four passes was made in each patient. In no **procedure** did a complication occur.

(Figures 2-3 ILLUSTRATION OMITTED)

Table 1--Comparison of **Methods** to Types of Hospital Laboratory

	Hospital Category		
	Community (n = 89)	University (n = 38...	Children's

...01 compared to community and children's hospitals.

A diagnostic result was obtained in six **lesions** , including two from right paratracheal nodes, two from subcarinal nodes, one from left paratracheal nodes...

...but one patient, at least one readjustment using CT fluoroscopic assistance was required before successful **biopsy** . Each diagnostic result was neoplastic and consisted of metastatic non-small cell lung cancer in...

...small peripheral nodule revealed an identical pathologic diagnosis, thus confirming the site of the primary **lesion** (Fig 4). The mean size of successfully **biopsied** **lesions** (1.9 cm) was similar to that for all mediastinal **lesions** .

(Figure 4 ILLUSTRATION OMITTED)

Of nine patients for whom **biopsy** specimens were not diagnostic, two underwent subsequent mediastinoscopies that proved normal. In two patients , follow-up with **imaging** studies for at least 1 year revealed a stable appearance of the lymph nodes. In two **patients** , mediastinal sampling with **CT** fluoros copy-assisted **TBNA** was not diagnostic but **tumors** were

found at surgery. The **lesions** in these falsenegative eases were a 2.9-cm right hilar squamous cell carcinoma and...

...1.8-cm right paratracheal squamous cell carcinoma (Fig 5). In three patients with negative **TBNA** results, no follow-up evaluation was available.

(Figure 5 ILLUSTRATION OMITTED)

Lung **Lesions**

The 12 lung **lesions** included 6 distinct nodules or masses and 6 ill-defined areas of lung consolidation with a mean **diameter** of 2.2 cm (range, 1.0 to 3.0 cm). The location of nodular **lesions** was evenly distributed. Three occurred in the upper lobe, including two on the left and one on the right (Fig 6). Right middle lobe, lingular, and left lower lobe **lesions** accounted for one **lesion** each. A diagnostic pathologic specimen was obtained in four patients, all of whom had non-small cell lung cancer. One patient who had undergone a nondiagnostic CT fluoroscopy-guided **TBNA** proved to have a metastatic spindle cell sarcoma at surgery. The remaining lung **lesion** resolved spontaneously as demonstrated on a follow-up CT scan (Table 2).

(Figure 6 ILLUSTRATION OMITTED)

Table 2--CT Fluoroscopic-Guided **TBNA** Results in Lung **Lesions** (*)

Patient No.	Age, yr	Sex	Underlying Disease	Location
1	41.	M	Pancreatitis	RUL
2	58...			
...10	56	M	Leukemia/neutropenia	RUL
11	41	M	Lymphoma/neutropenia	Lingula
12	28	F	**Tumor** /bone marrow transplantation	RUL

Patient No.	**Lesion** Type	Size, cm	**TBNA** Result
1	Nodule	1.80	Positive
2	Nodule	2.00	Positive
3	Infiltrate	1.00...	

...infectious origin for the areas of consolidation. One patient with normal findings for CT fluoroscopy- **guided bronchoscopy** and persistent consolidation was found to have aspergillosis at subsequent **bronchoscopy** .

(Figure 7 ILLUSTRATION OMITTED)

The overall accuracy of CT fluoroscopy-guided **TBNA** was 10 of 12 mediastinal **procedures** (83%) and 8 of 12 lung **procedures** (67%). The three patients for whom no follow-up assessment was available are not included in these data. Specific diagnoses were obtained in 6 of 15 mediastinal **procedures** (40%) and in 7 of 12 lung **procedures** (58%). No serious complication occurred in any **procedure** .

The mean duration of the **procedure** from first to last CT scan among the 17 patients in whom this information was...

...In most patients, the use of a 30-mA technique was sufficient to achieve good **image** quality. In larger **patients** with mediastinal **lesions** , a 50-mA technique was sometimes necessary.

TBNA of solitary pulmonary nodule. Top: preprocedure CT shows a 1.8-cm right upper lobe nodule. Note that a bronchus extends directly to the **lesion** . Bottom: frames from a CT fluoroscopy sequence demonstrate the **TBNA** needle within the **lesion** . Diagnosis was non-small cell lung cancer.

DISCUSSION

Tissue samples of a suspicious intrathoracic **lesion** can be obtained with several techniques. The most widely used are percutaneous needle **biopsy** , **TBNA** with flexible **bronchoscopic** guidance, and surgery.(3) The approach that is selected depends on the location and extent...
...is often undertaken. However, if the enlarged lymph nodes are within reach, either percutaneous needle **biopsy** or **TBNA** can be performed less invasively.(1)

TBNA with **bronchoscopic** guidance is a valuable technique to sample abnormal lymph nodes that are located near an...

...accessible. In some instances, hilar nodes can also be aspirated.(1) One important disadvantage of **TBNA** as compared with surgical techniques is that the target node is not visible through the **bronchoscope** . Thus, the **bronchoscopic** needle may be advanced through the airway wall based on landmarks identified on the preprocedure...

...and distortions, bulges, or alteration of the bronchial epithelium of the airway encountered during the **procedure** .(1) The introduction of spiral CT has permitted volume rendering of the airways, producing a three-dimensional endoluminal perspective that is termed virtual **bronchoscopy** .(11) A second **method** is the use of a sensor at the tip of the **bronchoscope** in combination with a previously acquired three-dimensional CT data set to localize target **lesions** .(12) However, real-time imaging is not achieved with either technique.

TBNA is typically performed blindly, but a potential approach is to use conventional fluoroscopy to **guide** the **bronchoscopic** positioning. However, conventional fluoroscopy is limited by suboptimal contrast resolution and superimposition of structures in...

...fluoroscopy to provide adequate visualization of the target lymph node has hindered widespread use of **TBNA** to the **biopsy** of mediastinal **lesions** . Moreover, it has fostered the perception that **TBNA** is difficult and potentially risky and, therefore, should be undertaken only by experienced **bronchoscopists** .(1,13,14) The sensitivity of **TBNA** in several series is approximately 50%, and overall results are inferior to surgery.(3,4,15) Thus, many patients who might be candidates for **bronchoscopically guided TBNA** are referred for surgery.

More recently, the use of ultrasonography has been advocated to provide guidance for **TBNA** .(15) A sonographic probe is **inserted** through a port in the **bronchoscope** and can demonstrate the relationship of the **bronchoscope** to the adjacent enlarged lymph nodes. In the report of Shannon et al(15) 82 **procedures** were performed in 80 patients who were randomized into standard (n = 40) and ultrasoundguided (n = 42) **TBNA** groups. The authors found no statistically significant difference in sensitivity between the two groups (standard, 91%; ultrasoundguided, 83%). The major benefit reported for ultrasound-guided **TBNA** was a decrease in the required number of nodal aspirates.

Although sonographic guidance of **TBNA** may ultimately prove useful, the technique currently suffers from two limitations.(7) First, the diagnostic...

...sonographic probe is variable; it may be difficult to distinguish the target nodes from other **anatomic structures** . Thus, the technique is highly **operatordependent** . Second, the **bronchoscopic** port that is used for the ultrasound probe is the same as that through which the **biopsy** needle is passed. The probe must be withdrawn and the **bronchoscopic** position maintained while the needle is inserted. Therefore, real-time visualization of needle location is not achieved.

Standard CT can also be used to image the location of the

bronchoscope within the airway in relation to the target lymph nodes. Rong and Cui(6) reported...

...patients with malignant mediastinal adenopathy using standard CT scanning to assure proper needle location during **TBNA** **biopsy** . They noted substantial improvement in their diagnostic yield as compared with their previous sensitivity (20...

...as the appropriate slice position is found, the technologist prescribes the sequence and scans the **patient** , and the **image** reconstructs. While this occurs, the **bronchoscope** must be maintained in a constant position, often for several minutes. This time-consuming **process** must be repeated with each adjustment of the **bronchoscope** for which CT localization is desired. Thus, either the number of imaging sequences must be minimized or the **procedure** **length** must be increased substantially. Ewart et al(16) also reported favorable results with CT guidance of **TBNA** in right paratracheal nodes.

The real-time capability of CT fluoroscopy obviatesmany disadvantages of other techniques in the optimal guidance of **TBNA** .(7,17) In our study, CT fluoroscopy enabled rapid localization of the position of the **bronchoscopic** tip after each movement on the in-room monitor. The needle was observed as it was planted in the airway to assure that it was directed toward the intended **biopsy** site. Once the needle had been advanced, CT fluoroscopic images provided assurance that the needle was in the target **lesion** . Although both the 21-gauge and 19-gauge aspiration needles were readily visualized, the latter was more easily identified. The **bronchoscope** caused a substantial artifact but did not interfere with identification of the needle position. The artifact created by the **bronchoscope** usually did not appear when subcarinal nodes were aspirated because the needle and **bronchoscope** were not in the same imaging plane.

(Figure 8 ILLUSTRATION OMITTED)

The feedback provided by...

...occurred during our study, we performed a CT fluoroscopic sequence immediately on completion of the **procedure** , which would have permitted immediate detection of and intervention for pneumothorax or hemorrhage.

Several likely...

...cm) and therefore constitute a subset that is known to be difficult to diagnose by **TBNA** . Several patients had undergone previous **TBNA** using conventional fluoroscopic guidance without diagnosis, creating a selection bias toward more difficult **lesions** . In one **patient** , the **CT** fluoroscopic **image** demonstrated that the needle **length** was insufficient to reach the target node. In another patient, sampling error was a contributing...

...only lymphocytes were aspirated from a right hilar mass in which CT fluoroscopy showed the **TBNA** needle in the mass, but at surgery, a central squamous cell carcinoma of lung was diagnosed.

The choice of approach to **biopsy** of a lung nodule or mass depends on several factors including the location of the **lesion** and physician preference and expertise. In general, peripheral subpleural **lesions** are sampled using percutaneous needle aspiration or **biopsy** ,is **Bronchoscopy** with transbronchial **biopsy** or **TBNA** is often preferred in patients with more central **lesions** , particularly if a bronchus is observed extending into the **lesion** on CT.(19) Two recent studies have demonstrated the value of **TBNA** in the diagnosis of pulmonary nodules.(20,21)

Large central **lesions** are readily diagnosed by **bronchoscopy** with or without fluoroscopic guidance. Smaller **lesions** provide a more formidable challenge and thus often require fluoroscopic guidance. When

grasped by the **biopsy** forceps, the movement of a peripheral nodule or mass using a C-arm under fluoroscopic visualization provides strong evidence that the **lesion** has been sampled. Nevertheless, the two-dimensional display format of conventional fluoroscopy results in overlap...

...easier selection of the appropriate bronchus. Of particular interest was the ability of CT-guided **TBNA** to assist in diagnosing invasive aspergillosis in small peripheral inflammatory **lesions** in severely immunocompromised patients. However, the bronchus to the target **lesion** could not be reached in all patients with discrete nodules. In patients with ill-defined nodules or airspace disease who had proved or presumed infection, the **bronchoscopic** needle was advanced successfully into each **lesion** under CT fluoroscopic guidance, although a diagnosis was not established in three patients. These patients...

...including antifungal agents, and this factor may have contributed to a false-negative result.

The **TBNA** needle was reliably identified as a small metallic density in the lung using CT fluoros copy. The forceps **biopsy** needle used for transbronchial **biopsy** appeared somewhat denser, and its serrated teeth were sometimes recognizable. In one patient, a lavage...

...small focal infiltrate.

Although many of the patients in whom we performed CT fluoroscopy-guided **TBNA** had small **lesions** or had undergone previous attempt at **bronchoscopic** **biopsy** without such guidance, our results are similar to those reported in the literature for both...

...current study is limited by small sample size, but the results suggest that CT fluoroscopy- **guided** **TBNA** holds considerable promise. The **procedure** **length** is somewhat longer than typical, presumably because of the selection of difficult cases. Another limitation...

...the study is the lack of a control group that would include patients with similar **lesions** who had undergone **TBNA** without CT fluoroscopic guidance. Comparison of **TBNA** with and without CT ...dose to a narrow area. The radiation dose is further dissipated because the sliding table **method** used for this **procedure** limits exposure to any particular region.

Daly et al(22) investigated 31 patients who had undergone thoracoabdominal interventional **procedures** with CT fluoroscopic guidance using thermoluminescent dosimetry and found maximum skin doses ranging from 0...

...dose" threshold level defined by the US Food and Drug Administration.(23,24) For lung **procedures** , the dose factors that affect the cumulative skin-entry dose might be further reduced because of the high contrast between aerated lung **lesions** and focal lung **lesions** .(17)

CT fluoroscopic guidance of **TBNA** is likely to benefit **bronchoscopists** who have been hesitant to use **TBNA** because it provides a better road map for the **procedure** . Moreover, it may allow **bronchoscopists** who have more experience with **TBNA** to use larger needles in the mediastinum, because of increased confidence of needle position in ...

...sampling of smaller nodules and those in more difficult locations, potentially increasing the yield of **TBNA** in peripheral pulmonary **lesions** .

ACKNOWLEDGMENT: The authors thank Barry Daly, MD, for his assistance in providing radiation data for CT fluoroscopic **procedures** .

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DESCRIPTORS: **Biopsy** , Needle...

... **Biopsy**
20001201

29/5,K/30 **(Item 10 from file: 149)**

01928950 SUPPLIER NUMBER: 64189458 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Novel Flexible Bronchoscope **and Single-Use Disposable-Sheath** Endoscope System **(*)**.
Colt, Henri G.; Beamis, John J. F.; Harrell, James H.; Mathur, Praveen M.
Chest, 118, 1, 183
July,
2000
PUBLICATION FORMAT: Magazine/Journal; Refereed ISSN: 0012-3692
LANGUAGE: English RECORD TYPE: Fulltext TARGET AUDIENCE: Professional
WORD COUNT: 2811 LINE COUNT: 00306
FILE SEGMENT: HI File 149

Novel Flexible Bronchoscope **and Single-Use Disposable-Sheath** Endoscope System **(*)**.

TEXT:

Objective: To measure image clarity, ease of use, and **handling** performance of a flexible fiberoptic **bronchoscope** (B-F 100; Vision Sciences; Natick, MA) and sterile single-use disposable-sheath **endoscope** **system** (BS-F21 EndoSheath; Vision Sciences).
... by the US Food and Drug Administration.

Setting: Three tertiary care referral centers with busy **bronchoscopy** practices.

Patients: Twenty-four patients undergoing **bronchoscopy** with a flexible fiberoptic **bronchoscope** and disposable sheath **endoscope** **system** .

Methods : Flexible **bronchoscopy** was performed through a transnasal or transoral route after topical upper airway anesthesia using standard techniques. After each **procedure** , the **bronchoscopist** rated the performance of the medical device under study using a linear scale of 1 (poor) to 5 (excellent and equal to that of a conventional flexible fiberoptic **bronchoscope**).

Results: Mean performance ratings were (is greater than) 4.0 (range, 4.17 to 4...

...greater than) 3.0 (range, 3.54 to 3.87), the lowest of which was **handling** comfort.

Conclusion: The flexible fiberoptic **bronchoscope** with sterile single-use disposable-sheath **endoscope** **system** has the potential to reduce scope downtime by eliminating the need for high-level disinfection between **procedures** . Illumination, image clarity, and ease of insertion are very good, justifying future prospective studies comparing this device to conventional flexible fiberoptic **bronchoscopes** .

(CHEST 2000; 118:183-187)

Key words: **bronchoscopy** ; infection control; technology; vision sciences

A Preliminary Technology Evaluation

High-level disinfection of flexible fiberoptic **bronchoscopes** is a time-consuming and potentially costly **process** .(1,2) Multiple investigators have examined the need for careful disinfection to avoid inadvertent pseudoinfection or transmission to **patients** of microbial **pathogens** present on flexible **bronchoscopes** or in various **processing** devices.(3-9) In addition, the downtime of at least 30 to 60 min required for cleaning, disinfection, and drying of these costly instruments between **procedures** requires centers with substantial **bronchoscopy** activity to purchase multiple **bronchoscopes** in order to ensure that interventions occur in a timely and efficient manner.

The purpose of this study was to perform a diagnostic technology evaluation from the **bronchoscopist** 's perspective of a novel flexible fiberoptic **bronchoscope** (B-F 100; Vision Sciences; Natick, MA) that uses a prepackaged, presterilized, single-use **endoscope** sheath **system** (BS-F21 EndoSheath; Vision Sciences) containing a working channel to cover and protect all surfaces of the **bronchoscope** from contamination.

MATERIALS AND **METHODS**

Study Protocol

The protocol for this study was written and executed by the authors at...

...were chosen by the manufacturer. The investigators at each of the chosen centers have busy **bronchoscopy** practices and prior experience in the assessment and development of novel **endoscopic** technologies. Informed consent was obtained from patients before undergoing **bronchoscopy** .

Novel Flexible Fiberoptic **Bronchoscope** and Single-Use **Endoscope** Sheath **System**

The **bronchoscope** used is a reusable, fully immersible, D-shaped flexible fiberoptic **bronchoscope** , with a working **length** of 55 cm, 90 (degrees) field of view, 3- to 50-mm **depth** of field, and angulations of 180 (degrees) up and 130 (degrees) down (Fig 1). Contrary to conventional flexible fiberoptic **bronchoscopes** , this D-shaped scope has no indwelling working or suction channel, using instead an attachable, disposable, prepackaged, presterilized, single-use **endoscope** sheath made of a colorless thermoplastic elastomer with an optically clear distal window that completely covers the distal tip of the **bronchoscope** (Fig 1). The sheath contains a 2.1-mm working channel for suction, fluid injection, or passage of accessory instruments (Fig 1). Once fully sheathed, the outer **diameter** of the **bronchoscope** is 6.1 mm. The **endoscope** sheath is specially designed for use with the B-F 100 flexible **bronchoscope** and cannot be used over existing Olympus (Melville, NY) or Pentax (Orangehurg, NJ) flexible fiberoptic **bronchoscopes** .

(Figure 1 ILLUSTRATION OMITTED)

The single-use **endoscope** sheath is designed to isolate the **bronchoscope** from contact with the patient, eliminating the need for high-level disinfection of the **bronchoscope** between cases. This technology provides a sterilized instrument to the patient and reduces exposure of...

...suction pump or other suitable vacuum source (Fig 1). To install the sheath onto the **bronchoscope** , the D-shaped **bronchoscope** is **inserted** into the D-shaped opening of the sheath housing until the distal tip reaches the...

...the sheath to conform to the scope. Proper seating of the distal extremity of the **bronchoscope** in the sheath window is verified by

visualizing a clear image with the **bronchoscope** connected to a light source. The integral hand cover of the sheath is pulled over the controls of the **bronchoscope** and light **guide** cable until it completely covers the body and eyepiece. The handle cover is secured using...

...instrument is removed from the installation tube (Fig 2).

(Figure 2 ILLUSTRATION OMITTED)

After the **bronchoscopic procedure** is completed, the contaminated sheathed **bronchoscope** is placed back into the installation tube, cover clips are removed, and vacuum is reapplied until the uncontaminated D-shaped **bronchoscope** can be gently removed from the sheath. When sheaths are apllied and handled properly, there is minimal risk of accidental exposure to potential contaminants. In the event that the **bronchoscope** is contaminated, however, high-level disinfection or ethylene oxide sterilization is possible.

Procedures and Technology Evaluation

Bronchoscopy was performed using a transnasal or transoral approach after topical upper airway anesthesia using standard techniques. After each **procedure** , the **bronchoscopist** completed a 5-point scoring sheet, where 1 corresponds to poor, and 5 corresponds to excellent (meant to reflect similarity to the properties of a conventional flexible fiberoptic **bronchoscope**), to evaluate 12 different aspects of use pertaining to visualization, ease of **handling** , and **operational** components of **bronchoscope** performance. At the end of the study period, scores were tallied, and mean values for...

...with which fogging could be avoided, and fiberoptic to video image clarity when attaching an **endoscopic** video camera to the head of the flexible fiberoptic **bronchoscope** using a standard C-mount adapter; (2) handling--as defined by overall feel and handling...

...channel.

RESULTS

Twenty-four patients at three institutions participated in this study. None of the **procedures** were terminated prematurely because of instrument malfunction, although an **operator** switched to a conventional **bronchoscope** on one occasion. **Bronchoscopists** in two of the participating institutions noted that the conversion of the fiberoptic-derived image was not always ideal when a video camera was placed onto the head of the **bronchoscope** using a standard C mount. It was also occasionally difficult to insert a slip-tip...

...of the performance scores for the 12 components assessed are listed in Table 1. Overall, **bronchoscopists** believed that the device performed adequately for suctioning and use of accessory instruments. The highest...

...average, probably because investigators were unfamiliar with the new feel of the B-F 100 **bronchoscope** , the proximal extremity of which is more narrow than that of conventional Olympus or Pentax flexible fiberoptic **bronchoscopes** .

Table --Performance Scores (12 Components) for Flexible Fiberoptic **Bronchoscope** and **Endoscope** Sheath **System** (*)

Study Site/ **Patient**	**Image** Clarity	Fiberoptic to Video Conversion Clarity	Illumination	Fogging
Study site I				
1	5	5	5	5
2	4	4	5...	

...University Medical Center).

DISCUSSION

The results of this preliminary evaluation demonstrate the acceptable optics and **handling** profile of this novel **system** . We believe this justifies consideration for its introduction into general **bronchoscopic** practice, particularly since the **system** has been approved by the US Food and Drug Administration, and similar **systems** are already being used for flexible sigmoidoscopy(10) and nasopharyngeal laryngoscopy.(11)

Current technology does not allow incorporation of a distal charge-coupled device into the D-shaped flexible **bronchoscope** . Video documentation and observation, therefore, is only possible using an attachable camera and C-mount...

...environment of today, it appears that many pulmonologists prefer videobronchoscopy, which is also the preferred **method** for **bronchoscopy** in a teaching environment. It is likely that this potential shortcoming of the Vision Sciences **system** , which could be a serious limitation for academic institutions where video **systems** are used, could be addressed in the future when distal video chip size reduction becomes possible.

Our results also suggest, however, that the disposable **endoscope** sheath **system** requires more fine tuning. This information should be available to anyone considering purchase of this device. For example, improper loading of the sheath can result in contamination of the **bronchoscope** . The consequent need for disinfection eliminates many of the major advantages of the **system** . In addition, if the sheath is placed incorrectly over the tip of the **bronchoscope** , visualization is impaired because of a bright glare that has the appearance of one or...

...light from the optical bundle onto the inner surface of the sheath.

Investigators and their **procedure** assistants unanimously agreed that in order to ensure proper loading of the sheath onto the **bronchoscope** , focused training and education of **bronchoscopy** nurses and technicians was required. In fact, several experienced assistants from each of the three participating institutions complained about the need for using a second **endoscope** sheath when the first sheath could not be properly loaded onto the flexible **bronchoscope** . Repeated encounters of such difficulties incur increased **procedure** -related costs. As of this writing, the purchase price for a single-use **endoscope** sheath is approximately $100. Because of decreasing Medicare reimbursement schedules for flexible **bronchoscopy** and competitive pricing in an expanding managed care market, it is reasonable to suggest that...

...of the device being studied. In fact, no attempt was made to simultaneously compare the **system** with a conventional flexible fiberoptic **bronchoscope** by performing two **bronchoscopies** in each patient (one with the device being studied, and one with a conventional **bronchoscope**). This is because the purpose of this preliminary work was to address from a **bronchoscopist** 's perspective the single aspect of acceptability as defined by ease of handling, visualization, and **operational** components of a novel **bronchoscopic** **system** . More comprehensive assessments are required to study potential benefits of this **bronchoscope** compared to conventional **systems** , as well as to address cost-effectiveness, patient satisfaction, and technical assistance issues.

Whether this **system** is clinically beneficial will also require further study. Potential applications are settings where damage to a conventional flexible **bronchoscope** is possible, such as during **transbronchial** **needle** **aspiration** , or when there are infection-control and cross-contamination concerns, such as in patients with mycobacterial

infections or HIV.

Single-use **endoscope** sheath **systems** might also be warranted for exceptionally busy **bronchoscopy** services, if turnaround time proves to be faster than with conventional flexible **bronchoscopes** . Less busy **bronchoscopy** services might be interested in this device if they could avoid purchasing numerous conventional **bronchoscopes** , relying instead on a single instrument and disposable sheaths on days when multiple **procedures** are required. Finally, flexible **bronchoscopy** might be more readily available to patients in settings such as primary care clinics, mobile...

...disinfection or sterilization equipment is not readily accessible. In fact, the use of single-use **endoscope** sheaths might considerably decrease scope downtime, facilitating multiple **bronchoscopic** **procedures** for aspiration of secretions in patients receiving mechanical ventilation.

In summary, the results of this preliminary technology evaluation convincingly demonstrate the effectiveness of a novel **system** employed for **bronchoscopic** inspection, **biopsies** , washings, and brushings. As we enter the 21st century, **bronchoscopists** and medical device manufacturers alike must consider new approaches to traditional **procedure** -related problems. The concept of a single-use sheath with an incorporated working channel represents an original approach to several otherwise unexplored issues pertaining to flexible fiberoptic **bronchoscopy** .

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...Natick, MA, who provided the investigators with a Vision Sciences B-F 100 flexible fiberoptic **bronchoscope** , BS-F21 EndoSheath **bronchoscope** barriers, and technical support as needed at no cost throughout the duration of the study...

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29/5,K/32 (Item 12 from file: 149)

01899917 SUPPLIER NUMBER: 61523913 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Image-guided Percutaneous Needle Biopsy : **An Overview.**
LONG, BRUCE W.
Radiologic Technology, 71, 4, 335
March,
2000
PUBLICATION FORMAT: Magazine/Journal; Refereed ISSN: 0033-8397
LANGUAGE: English RECORD TYPE: Fulltext TARGET AUDIENCE: Professional;
Trade
WORD COUNT: 15583 LINE COUNT: 01363

DESCRIPTORS: **Biopsy** , Needle--Usage; Diagnostic imaging--Innovations
GEOGRAPHIC CODES/NAMES: 1USA United States

Image-guided Percutaneous Needle Biopsy : **An Overview.**

TEXT:

Image-guided percutaneous needle **biopsy** (IGPNB) is a valuable tool for diagnosis of nonpalpable or deep-seated **lesions** that cannot be characterized definitively with diagnostic imaging alone. The **procedure** entails **inserting** a needle through the skin into an area of suspected pathology under the guidance of...

...development, indications, contraindications, patient preparation, equipment and possible complications of IGPNB, with particular attention to **biopsies** of the thorax, breast, abdominal organs, head and neck and the musculoskeletal **system** .
... radiographs are taken. The radiographs reveal a right hilar mass. The patient is referred for **bronchoscopy** , which is negative.

A postmenopausal woman keeps the appointment for her annual screening mammogram. She...

...age man with prostate cancer complains of pain in his right buttock area. An osteolytic **lesion** , inconsistent with prostatic metastasis, is seen in the right ischium on a pelvis radiograph. There...

...However, they have one thing in common -- all are candidates for image-guided percutaneous needle **biopsy** (IGPNB).

In general terms, a percutaneous needle **biopsy** (PNB) **procedure** entails **inserting** a needle through the skin and into an area of suspected pathology to retrieve a sample of the tissue or fluid for analysis. The **procedure** is considered a closed **biopsy** , as opposed to an open or surgical **biopsy** . The needle insertion can be nondirected (ie, performed without direct visualization of the target tissue...

...placement in the tissue to be sampled. The nondirected technique is used frequently when the **lesion** is palpable, whereas PNB is performed with image guidance when the **lesion** is deep-seated and nonpalpable.

Image-guided percutaneous needle **biopsy** is divided into 2 procedural areas, fine-needle aspiration **biopsy** (FNAB) and percutaneous core needle **biopsy** (PCNB), that differ in both **process** and product. FNAB, also called fine-needle aspiration cytology, is used when cellular specimens are collected from a **lesion** for cytologic or microbiologic analysis. Small fragments of tissue can be provided by an FNAB, but these fragments often are insufficient for histology purposes. PCNB, also called core needle **biopsy** , percutaneous core **biopsy** or percutaneous cutting needle **biopsy** , is performed when a tissue specimen is required for

histologic evaluation. Although the IGPNB **procedure** is common in current radiologic practice, there has been historical resistance to the **procedure** as a viable alternative to open, surgical **biopsy** .(1)

History

Techniques for PNB have been described in the literature since the mid 19th...

...United States were not published until the 1930s.(5-8) During that period, open surgical **biopsy** was the established **method** , so these early articles had little effect on the practice of **tumor** diagnosis.(9)

The progress of IGPNB has paralleled advances in imaging techniques. By the end...

...the 1930s, radiographic and fluoroscopic guidance had become a more important part of the IGPNB **procedure** in the chest and abdomen.(10-12) The development of image intensification for fluoroscopy allowed...

...17,18) and magnetic resonance imaging (MR) in the mid 1980s.(19,20)

Advances in **biopsy** needles and percutaneous **biopsy** **system** design have improved the safety and tissue yield of these **procedures** . Smaller **diameter** needles with improved tissue-cutting features allow multiple passes into a **lesion** with minimal complications and retrieval of quantities of **lesion** material sufficient for both histologic and cytologic evaluations.(21) In addition, the diagnostic quality of...

...assessed immediately and the cytology personnel can gather pertinent clinical information.(22,23) Although IGPNB **procedures** have been performed in the United States since the late 1920s,(5) they have been...

...guided PNB has developed into a valuable tool for diagnosis of nonpalpable or deep-seated **lesions** that cannot be characterized definitively by their appearance on diagnostic images. If the **lesion** is easily palpable or clearly warrants surgical intervention, IGPNB often is unnecessary. The IGPNB **procedure** is useful to differentiate a malignant from a benign condition and to provide material for cytologic, microbiologic, histologic and chemical analyses. The techniques and materials used depend on the location, **characteristics** and visibility of the **lesion** .(24)

The principal goals of IGPNB are to decrease the need for surgical **biopsy** and to determine the nature of a **lesion** before nonsurgical treatment. This practice is driven by the desire for minimally invasive diagnostic **procedures** and by economic forces. An IGPNB is easier on the patient and costs less. Even if the cost of the **procedure** were the same as for a surgical **biopsy** , hospitalization is usually unnecessary for IGPNB, thus decreasing the overall cost of patient management.(26...

...IGPNB, especially if fine needles are used. Because bleeding is a common complication of these **procedures** , patients with uncorrectable bleeding diatheses may not be good candidates, especially for IGPNB using large...

...lie in the required position also may be contraindications to IGPNB. In addition, the IGPNB **procedure** may be contraindicated when there is no clear, safe path to the **lesion** . However, many intestinal structures may be penetrated by fine needles with only rare complications.(24...covering the IGPNB technique for each anatomical region. Complication rates can be minimized with adequate **patient** preparation and prebiopsy **planning** .

Patient Preparation and Management

The IGPNB patient should be questioned regarding known coagulation disorders, easy bruising...

...corrected before attempting IGPNB.

Patients who will receive potentially nephrotoxic, iodinated contrast media during the **procedure** should be assessed for adequate renal function. Blood urea nitrogen (BUN) and creatinine levels are...

...for this purpose. Acceptable limits for these tests are institution specific.

Before beginning an IGPNB **procedure** , the **process** , benefits, all possible procedural risks and reasonable alternative diagnostic **procedures** should be fully discussed with the patient. The physician who presented the information, the patient and at least one witness who will not participate in the **procedure** must sign the procedural consent form.(31) The consent form should be signed by the...

...any medications are administered that may alter lucidity.

The patient should be monitored throughout the **procedure** for signs of distress, especially if sedation, narcotics or tranquilizers are administered. These medications, especially in combination, can adversely affect the cardiovascular and respiratory **systems** . The physician performing the IGPNB should have a thorough understanding of the potential effects of...

...to treat them.(25)

Outpatients may be observed for 1 to 4 hours following the **procedure** , depending on the institution, the patient and the **procedure** . The standard time period may be extended if larger caliber needles are used or if...

...and Berlin(32) contend that the interventional radiologist's patient care responsibilities have increased as **procedures** have become more invasive. They recommend that the radiologist initiate immediate treatment when a complication occurs while the **patient** is in the **imaging** suite. In addition, the radiologist should play an active role in managing the patient after...

...to the appropriate care unit. This includes offering differential diagnoses and suggesting additional diagnostic imaging **procedures** .

Image Guidance For Percutaneous Needle **Biopsy**

Imaging techniques used to guide IGPNB include radiography, fluoroscopy, sonography, CT and MR. Radionuclide imaging...

...choice of technique often is based on personal preference and previous experience.(25,33,34) **Lesion characteristics** such as visibility, size and location influence the choice of guiding technique. Cost, safety and...

...accomplished using radiography. Currently, use of radiographs is limited to visualization and approximate location of **lesions** . Mammography is used for placement of marking needles to direct surgical **biopsy** and may be used to guide FNAB or PCNB.

Although the majority of IGPNB **procedures** are **guided** with sonography or CT, fluoroscopy still is used for peripheral pulmonary **lesions** , for structures in the abdomen that can be opacified by an appropriate contrast medium(35) and for some skeletal **lesions** . Fluoroscopy has the advantages of low cost and wide availability but is limited by poor...

...widely used as a guidance technique for IGPNB. Advantages include accurate demonstration of anatomy, fast **procedure** time, real-time needle visualization similar to fluoroscopy, guidance in multiple imaging planes and portability...

...structures such as retroperitoneal fat or breast parenchyma. Sonographically guided PNB is difficult for deep **lesions** and in obese patients.(33) A variety of techniques have been devised to improve sonographic...

...as an image guidance technique for IGPNB of all body regions. Excellent spatial resolution of **lesions** is a major advantage of CT. A wide range of tissue densities can be demonstrated...

...the axial plane. Because the CT image displays a 360o view of structures surrounding the **lesion** , a number of alternate needle paths can be considered and the safest one selected.(34) CT is an excellent choice for needle **biopsy** of deep **lesions** in the thorax, abdomen, pelvis, retroperitoneum and skeleton.(33) Critical areas such as those adjacent... 34)

A disadvantage of CT is the lack of continuous needle visualization during insertion and **biopsy** . However, scan times have been greatly reduced through the application of helical CT to IGPNB...
...of the scanner may be other disadvantages.(34)

MR guidance for IGPNB is appropriate for **lesions** that are not visible on other techniques. Some **lesions** , such as certain prostate cancers, liver metastases(38) and breast **lesions** ,(39) are visible only on MR. MR's high flow sensitivity allows demonstration of vascular...

...guidance have been slow image acquisition and poor access to the patient. However, open-bore **systems** with MR fluoroscopy are a promising new development.(41,42) (See Fig. 1.)

(Figure 1 ILLUSTRATION OMITTED)

Biopsy Needles

A variety of needles are available for IGPNB, some with broad applicability and some very specialized. They can be categorized in several ways -- either by **diameter** or by type of tissue specimen obtained. Fine or "skinny" needles generally are considered those...

...been devised to improve the quality and quantity of specimen retrieved. They vary in bevel **angle** , tip shape and ability to cut the specimen with the end or side of the needle. The commonly used Chiba(43) needle has an acutely **angled** (24 (degrees)) beveled tip and is used primarily to obtain aspiration **biopsies** of cellular components for cytologic evaluation. Other acutely beveled needles include the Menghini(44) and...
...Figure 2 ILLUSTRATION OMITTED)

Andriole and associates(51) assessed the tissue-cutting capabilities of various **biopsy** needles and concluded that for fine needles of the same caliber, acutely **angled** bevels yielded the greatest amount of tissue. However, they didn't assess the small caliber...

...Westcott needle that has been shown to consistently retrieve adequate cores of tissue.(50)

Larger **diameter** (18 gauge or greater) cutting needles are designed to retrieve cores of tissue suitable for...

...Turner and Menghini, or side cutting, such as the TruCut. The automated devices, commonly called **biopsy** guns, "throw" the needle several centimeters into the **lesion** , preventing the problem of **lesion** displacement by the needle tip that is sometimes encountered with a manual technique. (See Fig. 3.)

(Figure 3 ILLUSTRATION OMITTED)

Biopsy guns primarily use a TruCut-type slotted needle, although **biopsy** guns with end-cut needles have been introduced more recently. Available TruCut-type **biopsy** guns include the Biopty (Bard Urological,

Covington, Ga), the Monopty (Bard Urological, Covington, Ga), the...
...no significant difference in the quality or quantity of specimens collected. Examples of end-cut **biopsy** guns include the Autovac (Argon Medical, Sugarland, Tex), the Ultra-Vac (MD Tech, Gainesville, Fla...

...cut needles obtained high-quality tissue cores, they had a significantly greater percentage of zero **biopsies** (no tissue retrieved) than the Biopty device. However, the authors mention that a recently improved model of the Full-Core instrument appears to have a greatly reduced zero **biopsy** rate.(53)

A variety of specialized needles have been developed. Trephine (sawtooth or serrated tip) needles are available for **biopsy** of **lesions** deep within intact cortical bone, reducing the need for predrilling.(24) In addition, needles have...

...techniques. Teflon coating, surface etching(54) and corkscrew stylets(55) improve sonographic visibility of the **biopsy** needle. Increasing the percentage of copper in stainless steel needles reduces metal artifacts on MR...

...retrieve the sample and the type of tissue specimen needed for diagnosis of the suspected **lesion** . Either a single needle or a coaxial technique can be used to aspirate cellular material...
...the name implies, is performed with a single needle that is used to puncture the **lesion** and interposed tissues. The skin hole created is frequently smaller than with a coaxial **system** and the needle is in the tissue a shorter time. However, multiple needle passes require the repuncture of interposed tissues for each insertion into the **lesion** . These multiple ...number of pleural punctures is associated with an increased incidence of pneumothorax.(58)

The coaxial **system** was developed to allow multiple needle insertions into a **lesion** without the need to repuncture the skin and other interposed tissues. However, these **systems** create a larger skin hole and remain in the body longer than a single needle. A basic **system** consists of an outer needle **guide** and an inner **biopsy** needle. The guide needle is inserted to contact the surface of the **lesion** and then the **biopsy** needle is advanced into the **lesion** . **Systems** have been developed for both FNAB and PCNB. For IGPNB in the thorax, Tarver(59) recommends a coaxial **system** for smaller **lesions** and those that require extended imaging **procedures** for proper needle placement. In addition, the coaxial technique is preferred when on-site cytology...

...insertion technique used, a 10 mL or 20 mL syringe usually is attached to the **biopsy** needle, unless a **biopsy** gun is used. A vacuum is created by pulling back on the syringe plunger, either...
...Calif). While the vacuum is maintained, the needle is moved up and down within the **lesion** to dislodge cells and draw them into the lumen. (See Fig. 4.)

(Figure 4 ILLUSTRATION OMITTED)

Standard **procedures** , such as patient assessment, informed consent, sedation, analgesia, anesthesia, proper positioning for site exposure, site preparation and image guidance **method** , are usually the same regardless of the needle introduction **system** .

Specimen **Handling** , Preparation and Analysis

The final step in performing an IGPNB is proper handling, preparation and...

...flawlessly performed retrieval can be negated if the specimen is damaged. Adherence to strict specimen **handling** and preparation **procedures** is especially critical for FNAB because of the limited amount

of material collected.(60) Even...

...9) If an on-site cytology team is not available, the physician performing the IGPNB **procedure** should be familiar with slide preparation and fixation techniques.(61)

A cytotechnologist and cytopathologist prepare and analyze FNAB specimens. Because time is an important factor, both for the **biopsy procedure** and for specimen preservation and fixation, it is highly recommended that a cytology team attend the **procedure** .(60) They will be able to prepare the specimen for preservation and fixation immediately after...

...such as age, gender, clinical history and diagnosis, should be in the patient record, but **lesion** location and appearance are best obtained from the radiologist performing the needle **biopsy procedure** . Accurate cytologic analysis requires correlation with clinical data because the cytopathologist must determine if the...

...should be taken to avoid unnecessary tissue damage as the specimen is removed from the **biopsy** needle and the specimen should be placed immediately into a fixative solution, usually 10% neutral...

...of the specimen are time consuming and are not done at the site of the **procedure** . The more rapid frozen section technique, used for surgical **biopsy** , is not customarily used for tissue cores retrieved from a PCNB **procedure** .(64)

Although the procedural aspects discussed above represent the general IGPNB **procedure** , there are variations in technique for different body regions and organs. For purposes of discussion...

...be divided into 5 regions, including the thorax, breast, abdomen, head/neck and the musculoskeletal **system** . Each of these regions requires modifications to the standard **procedures** . In addition, specialized equipment has been developed to optimize specimen retrieval from varied tissues.

Thorax

Currently, there are 4 **methods** of obtaining lung tissue for cytologic, histologic and microbiologic evaluation. These include surgical **biopsy** , video-assisted thorascopic **biopsy** , transbronchial **bronchoscopic biopsy** and transthoracic needle **biopsy** (TNB). Choice of technique is determined by the location, size and suspected nature of the **lesion** . A surgical **biopsy** is appropriate if there is a high suspicion of malignancy that will require surgical resection. The thorascopic technique is used for peripheral pulmonary **lesions** near the pleural surface.(59) **Lesions** beyond the pleural surface may not be visible to the thoracoscopist, but can be marked with a mammographic localization wire to **guide** the thorascopic **biopsy** .(65) A **bronchoscopic biopsy** is preferred for more centrally located **lesions** with endobronchial involvement. A brush **biopsy** or transbronchial Wang needle **biopsy** may be performed through the **bronchoscope** .

The first transthoracic needle **biopsy** was reported by Leyden(66) in 1883. However, it wasn't until the mid 1960s...

...the lung.(67) As imaging and interventional techniques improved, TNB gained popularity as an effective **method** for evaluating thoracic **lesions** .

Transthoracic needle **biopsy** is appropriate under a number of conditions and may be the first choice in patients who are not surgical candidates because of known metastasis, an invasive **tumor** and poor pulmonary or overall physical condition.(68) It is an established diagnostic technique for extrathoracic malignancy or suspected metastatic disease and immunocompromised patients with suspected infectious **lesions**

.(58,59) A TNB may be used to assess a mediastinal mass(68) or to further evaluate a hilar mass or solitary nodule after a negative or indeterminate **bronchoscopy** .(69) In addition, the technique can be used to establish the benign nature of a **lesion** .(68) TNB may not be warranted when the probability for cancer is high or **biopsy** results are unlikely to affect treatment.

As with many interventional **procedures** , the contraindications to TNB are related to the associated procedural complications. There are no absolute...

...eg, severe chronic obstructive pulmonary disease (COPD), pneumonectomy, mechanical ventilation), bullae or emphysema in the **path** of the needle, **patient** inability to cooperate (eg, maintain a position or hold breath), intractable cough, a bleeding diathesis (clotting abnormality), pulmonary hypertension, vascular **lesions** and echinococcal (hydatid) cyst.(58,59,68)

The most common complications of TNB are pneumothorax...

...increasing the risk of pneumothorax include large needles ((is greater than) 18 gauge), deep-seated **lesions** , increasing numbers of pleural punctures, presence of emphysema or COPD, patient movement or coughing, advanced age and operator inexperience.(70) However, with improvements in needle **biopsy** techniques, these risk factors may change. For instance, recent research indicates that advanced age may...

...of pneumothorax.(71) Hemoptysis, indicating a pulmonary hemorrhage, occurs in 5% to 15% of TNB **procedures** .(68,70) Patients with an uncontrolled bleeding diathesis, pulmonary hypertension, vascular **lesions** , uncontrolled cough or an inability to remain still are at an increased risk for bleeding.

Rare complications of TNB include air or **tumor** embolism, bronchopleural fistula, lung torsion, **tumor** seeding along the needle track and significant bleeding incidents, such as massive hemoptysis, hemothorax or...

...assessing the patient for contraindications or for conditions that may require changes to the planned **procedure** . Choice of imaging technique for guidance is based on the size and location of the **lesion** , availability of the desired technique and the preference and experience of the radiologist. Fluoroscopy, CT and, less frequently, sonography are used. Fluoroscopy is particularly useful for smaller, peripheral **lesions** , especially in the lower third of the lungs where greater respiratory movement occurs.(59) Fluoroscopic TNB of small, central **lesions** has been found to result in decreased diagnostic accuracy.(72,73)

CT is recommended over fluoroscopy for TNB of small **lesions** near vascular structures or **lesions** that are difficult to see on fluoroscopy.(74) Another advantage of CT is the ability...

...equal to fluoroscopy,(73) but this may be related to the selection of more difficult **lesions** for CT-guided **biopsy** .(77)

Sonography is useful for **biopsy** of peripheral pleural consolidation and nodules adjacent to the pleura.(78-80) **Biopsy** of anterior mediastinal masses using sonography for guidance has been reported.(81,82)

Both aspiration and core cutting needles are used for TNB. Small-**diameter** needles such as the Chiba and Greene commonly are used for aspiration **biopsy** .(58,59) The Chiba type is used for the single-needle technique, whereas the Greene needle is a coaxial **system** consisting of a 19- or 22-gauge ultra-thin-walled outer needle with a smaller gauge inner needle. The single pass needle technique is appropriate for large, easily accessible **lesions** . Coaxial needle **systems** are best for smaller, more remote **lesions** that may require multiple needle passes or a **lengthy**

biopsy **procedure** .(59) (See Figs. 4 and 6.)

(Figure 6 ILLUSTRATION OMITTED)

Cutting needles are needed when the aspiration **biopsy** technique cannot provide sufficient tissue for a definitive diagnosis, when lymphoma is suspected, for the diagnosis of benign lung nodules and when immediate cytopathologic assessment of **biopsy** specimens is unavailable.(83,84) A variety of cutting needles are used for TNB, including...

...devices such as the Franseen or Westcott needles and automated devices such as the Biopty **biopsy** gun. The **lesion** size and proximity to vascular structures limit use of cutting needles, especially **biopsy** guns.(68) **Biopsy** of the parietal pleura requires cutting needles designed for that purpose, such as the Abrams...

...consequences of common complications -- pneumothorax and hemorrhage. The patient should be positioned so that the **biopsy** site is dependent, thus reducing the leakage of air from the lung into the pleural...

...100% of pneumothoraces large enough to require treatment occur within the first hour after the **biopsy** **procedure** .(58) Pneumothoraces requiting treatment frequently can be managed with small caliber (6 to 9 French... examined further using additional imaging studies, such as a sonogram. If the image of the **lesion** suggests malignancy, a **biopsy** may be warranted. The gold standard for breast **biopsy** is surgical excision of all or part of the **lesion** .(86) However, techniques for IGPNB of the breast have been developed to reduce the need for surgical **biopsy** in some categories of abnormalities identified on breast imaging studies.

In 1995, the American College of Radiology (ACR) published the Breast Imaging Reporting and Data **System** (BI-RADS).(87) This is a standardized **system** for the description of mammographic findings. A national task force, consisting of representatives from the...

...the College of American Pathologists, published a 1997 report(64) recommending stereotactic core needle breast **biopsy** for BI-RAD category 4 **lesions** (suspicious abnormality), many category 5 **lesions** (highly suggestive of malignancy) and, under certain conditions, category 3 **lesions** (probably benign findings). The report indicated that PCNB is most appropriate for category 4 **lesions** . The histologic evaluation of PCNB tissue cores can differentiate **lesions** that require surgical excision from those that can be followed with mammography and clinical assessment.

Both FNAB and PCNB are used for breast **biopsy** , with core needle **biopsy** more frequently chosen. Fine-needle aspiration **biopsy** has not gained the wide acceptance in the United States that it has in Europe for several reasons: a trained cytopathologist is required, disagreement exists over the accuracy of the **procedure** , the rate of insufficient samples is high and the current medicolegal environment is unfavorable to FNAB.(88-90) However, FNAB has been an accepted **method** for breast cancer diagnosis since 1970(91) and still is regarded as a valuable diagnostic...

...25-gauge) needles used result in relatively little pain or bleeding. Hematoma is uncommon and **tumor** seeding along the needle track has not been reported for breast FNAB.(86) Significant disadvantages to the **procedure** include the high number of insufficient **biopsies** (92) and the need for a pathologist experienced in evaluating the aspirates.(88)

PCNB can be used as the primary **method** of IGPNB in the breast or as an adjunct to FNAB when findings are equivocal...

...volume of intact tissue retrieved. These advantages include ease of pathologic evaluation, differentiation of benign **processes** and differentiation of invasive from intraductal or in situ carcinoma.(93,94)

Several authors who...

...to PCNB using stereotactic mammography guidance include patients too large to be accommodated by the **biopsy** equipment, breasts with an insufficient compressed thickness to allow the needle throw of **biopsy** guns, **lesions** too close to the skin, vague tissue **characteristics** or diffuse calcifications and inability of the patient to remain still between localization and needle placement in the **lesion** .(64)

The choice of imaging technique for IGPNB of the breast is based on **characteristics** of the **lesion** , such as visibility, location or presence of calcifications, and experience or preference of the practitioner...

...have been used successfully as guidance techniques, with stereotactic mammography the most popular.

Stereotactic mammography **systems** may be add-on devices for upright mammography units or freestanding prone stereotactic tables. Incorporating a digital imaging **system** makes it unnecessary to take and **process** mammograms during the **procedure** , thus reducing the **procedure** time.(94) The add-on devices are less expensive, work with existing equipment and allow...

...table requires a dedicated room but alleviates the need to stop diagnostic mammography during a **biopsy** **procedure** . The more recently developed stereotactic breast **biopsy** **systems** use the prone stereotactic table.

Sonography has several advantages as a guidance technique. As mentioned...

...inexpensive. The real-time capabilities of sonography allow continuous visualization of needle advancement into the **lesion** . Patients may lie supine and the breast need not be compressed.(98) (See Figs. 7 and 8.) Some **lesions** are visible only with sonography. When sonography is used as a guidance technique for IGPNB...

...8 ILLUSTRATION OMITTED)

Sonographic guidance also has drawbacks. Although up to 77% of mammographically suspicious **lesions** are demonstrable with sonography, those with isolated clusters of microcalcifications are not visible.(99) In ...

...simultaneous transducer manipulation and needle placement difficult to master.(98)

Although stereotactic mammography and sonography **guide** the majority of IGPNB **procedures** in the breast, other techniques have been used successfully. CT has been used for FNAB or PCNB of **lesions** that are difficult to localize with mammography or sonography.(86,100) MR with and without...

...enhancement has been used successfully for guidance of IGPNB and localization wire placement in breast **lesions** visible with MR alone(101,102) Stereotactic (framed(103,104) and frameless(105)) and freehand...

...breast using technetium Tc 99m sestamibi) has been used for needle localization prior to surgical **biopsy** of **lesions** exhibiting abnormally increased uptake.(108)

Prebiopsy patient assessment should include screening for significant coagulopathy or...

...vasovagal reactions are complications of IGPNB in the breast.(92) Depending on the needle guidance **method** used, the patient should be

screened to determine the ability to ...arthritis and spinal fusion may limit the patient's ability to lie prone on a **biopsy** table.(94) As with all invasive diagnostic **procedures** , informed patient consent is necessary. Standard protocol for obtaining consent should be followed.

Choice of equipment for IGPNB may be related to the radiologist's preference or the **characteristics** of the **lesion** . If FNAB is elected, fine-gauge aspiration needles, such as the Chiba, will be used. When PCNB is selected, either **biopsy** guns or other automated needle **biopsy systems** may be applied. The **biopsy** guns, first introduced for breast **biopsy** in 1990,(109) often use a TruCut-type needle and may be directed manually or with the aid of a stereotactic device.

Directional , vacuum-assisted breast **biopsy** **systems** such as the Mammotome (Ethicon Endo-Surgery Inc, Cincinnati, Ohio) have been developed to improve calcification retrieval and reduce underestimation of **lesions** containing atypical ductal hyperplasia or ductal carcinoma in situ.(110,111) (See Figs. 9 and...

...introduced to improve diagnostic yield(112) and allow placement of a localizing clip after small **lesions** have been completely excised.(113) Retrieval of 5 specimens is recommended to ensure a high...

...accuracy, but 10 or more specimens may be required if calcifications are present in the **lesion** .(114,115)

(Figures 9-10 ILLUSTRATION OMITTED)

Specimen handling for IGPNB of breast **lesions** is essentially the same as for other body regions. The presence of a trained cytopathologist ...

...Tissue cores from PCNB may be submitted to pathology in one container if a solitary **lesion** was **biopsied** , but samples from multiple **lesions** must be submitted separately and clearly labeled.(64) If the **lesion** contains calcifications, the tissue cores retrieved through PCNB should be mammographed to ensure that the...

...increases with use of larger caliber needles and may be increased when vacuum-assisted breast **biopsy** is performed.(111) Application of ice and direct pressure stop bleeding in most cases. However, more aggressive measures may be used for hemostasis after 11-gauge vacuum-assisted **biopsy** , including administration of a local anesthetic with epinephrine for deep anesthesia and wrapping the chest...

...complications and procedural aspects may differ.

Liver

There are currently 3 nonsurgical approaches to liver **biopsy** , including laparoscopy, the transvenous approach and the percutaneous route. Laparoscopy, by virtue of direct peritoneal...

...very effective for staging a variety of intra-abdominal malignancies. This technique is useful for **biopsy** in the cirrhotic liver and for diagnosis and staging of hepatocellular carcinoma.(118) The transvenous approach for liver **biopsy** , with access through the internal jugular or common femoral vein, is a viable alternative for patients with uncorrectable coagulopathy. Diffuse parenchymal disease may be evaluated by transvenous forceps **biopsy** from a hepatic vein.(27) The percutaneous route for liver **biopsy** , including both FNAB and PCNB, is less invasive than laparoscopy and more broadly applicable than the transvenous approach.

Although percutaneous liver **biopsy** first was performed in 1883,(1) it was not until the introduction of the "1-second technique" by Mengini(44) in 1958 that needle **biopsy** of the liver gained popularity. Currently, the liver is the most frequently **biopsied** abdominal

organ.(119) Broad indications for IGPNB of the liver include diffuse parenchymal diseases, focal **lesions** and tissue viability after transplantation.(118) (See Figs. 3 and 12.)

(Figure 12 ILLUSTRATION OMITTED...

...IGPNB of the liver include uncorrectable bleeding diatheses, absence of a safe route to the **lesion** ,(119) patient uncooperativeness, suspected echinococcal (hydatid) disease, hemangioma, significant ascites and infection in the liver...

...infections, bile peritonitis, various pleural cavity complications (eg, pneumothorax, hemothorax), reaction to anesthesia, needle breakage, **biopsy** of other organs, malignant tract seeding and death have been reported.(119,120,121)

Prebiopsy...

...image guidance is based on several factors, including the clinical situation, the visibility of the **lesion** and **operator** preference. As with most IGPNB **procedures** , sonography and CT are used most frequently. Sonography is desirable for real-time observation during needle insertion, but is limited by intervening air or gas and by difficulty imaging **lesions** under the anterior dome of the diaphragm. CT is chosen when the needle path or **lesion** is demonstrated more clearly.(119) (See Fig. 13.) MR-guided PNB is under development for **lesions** best demonstrated on MR. Both closed bore and open bore magnet **systems** have been used.(42,122,123)

(Figure 13 ILLUSTRATION OMITTED)

Both FNAB and PCNB are...

...radiologist's preference, the type of sample needed and the potential for complications. When core **biopsy** of vascular **lesions** is necessary, an 18-gauge cutting needle provides a sufficient tissue sample(124) and results in complication rates no greater than 21-gauge fine needles(33) as long as the **length** of interposing liver parenchymal track is not less than 1 cm.(125) When larger needles include assessment for complications. Most occur within 2 hours of the **procedure** and nearly all occur within 24 hours. Although pain is a common complaint, it is...

...more severe complications, such as hemorrhage or peritonitis.(118)

Pancreas

Three nonsurgical techniques for tissue **biopsy** have been applied to the pancreas, including endobiliary brush **biopsy** , **endoscopic** ultrasound- **guided** FNAB and IGPNB. Endobiliary brush **biopsy** of the pancreas, performed through a cholangiopancreatic **endoscope** , retrieves cellular specimens for cytologic evaluation and is limited to **lesions** involving the pancreatic ductal **system** .(128) Endosonographically **guided** FNAB, by virtue of high-resolution visualization of small pancreatic **tumors** and lymph nodes, has shown promise for needle aspiration **biopsy** of **lesions** within 2 to 3 cm of the stomach or duodenal wall.(129,130)

Indications for...

...the body or tail, unresectable carcinoma of the head, peripancreatic lymphadenopathy, characterization of some benign **lesions** , evaluation of pancreatic allo-graft and staging of a suspected or known malignancy for presurgical...

...CT guidance. Lees(129) states that the pancreas is the most dangerous abdominal organ to **biopsy** . Needle puncture of dilated biliary or pancreatic ducts should be avoided and fine needles should...

...the use of IV contrast media to extend IGPNB to diagnosis of renal cysts and **tumors** . Currently, sonography and CT are used most frequently for

guidance. Choice of technique depends on availability, preference of the practitioner, visibility of the **lesion** and contraindication to use of iodinated contrast media.

IGPNB of the kidney is used to differentiate a primary renal **tumor** from a metastatic or retroperitoneal **tumor** , or to provide tissue for histologic evaluation of diffuse parenchymal diseases. In addition, renal IGPNB can be used to characterize a suspected malignant **lesion** in patients who are poor surgical risks and to evaluate masses in patients on extended...

...current use of fine needles in the United States is controversial for all but cystic **lesions** and cases unsuitable for PCNB.(137) Because hemorrhage is a common occurrence, especially following PCNB...

...IGPNB. Both fine and cutting needles are used, depending on the location and type of **lesion** . The trend has been toward smaller gauge (18-gauge) **biopsy** guns, as opposed to the larger gauge (14-gauge) manual-cutting needles. Tissue sampling has...

...adrenal gland.(27) MR may allow differentiation between an incidental, nonfunctioning adenoma and a metastatic **lesion** in some cases.(24) However, when imaging is equivocal, IGPNB can be used to provide histologic evidence of malignancy for **tumor** staging and determining the appropriateness of surgery.(138)

CT is the common guidance technique, but sonography may be used. Although FNAB is used successfully for adrenal gland **biopsy** ,(141) PCNB is more common in the United States. Eighteen-gauge **biopsy** guns or 20-gauge cutting needles such as the Franseen(138) or Turner are used...

...Pelvic Masses and Organs

IGPNB may be used in the diagnosis of pelvic masses and **lesions** in organs such as the ovaries or prostate. The IGPNB technique is useful for staging...

...recurrence after surgical resection(33) and for evaluating non-neoplastic masses.(142) Approach to the **lesion** may be percutaneous, transvaginal, transcystic or transrectal, depending on the safest or shortest route.(27)

Both FNAB and PCNB techniques are used, with core **biopsy** preferred. CT is used frequently, but transabdominal sonography can be used when bowel gas does not interfere with visualization of the **lesion** .(138) Endosonography is standard for **lesions** that can be reached transvaginally or transrectally. For example, IGPNB of the prostate is carried out most frequently with endorectal guidance by the transrectal route using an 18-gauge automatic **biopsy** gun.(138,143) Complications from IGPNB in the pelvis are infrequent and usually are limited...

...can be subject to IGPNB. The technique is useful for diagnosis of lymphoma and for **tumor** staging to establish the presence of metastatic involvement. FNAB and PCNB are used for lymph node **biopsy** , and both provide sufficient material for diagnosis of primary and metastatic disease. However, PCNB often...FNAB may be performed with or without image guidance. Palpable, easily accessible masses may be **biopsied** without a guidance technique and may be performed with or without vacuum aspiration (ie, needle only).(145) Cutting-needle **biopsy** is performed customarily with image guidance. IGPNB of brain **lesions** requires stereotactic localization and guidance to achieve sufficiently precise needle placement. Sonography, CT and MR...

...those within the cranium.(147) Either CT or MR may be used for

stereotactic brain **biopsy** , depending on visibility or location of the **lesion** .(148,149) With the development of interventional MR scanners, head and neck **lesions** outside the cranium are now sampled by MR-guided PNB.(40,150)

Lesions in the thyroid or salivary glands, enlarged cervical lymph nodes and intracranial **lesions** are frequently subject to IGPNB. In addition, masses arising in and around the oral, nasal, orbital and pharyngeal cavities can be assessed. These mass **lesions** may result from primary **processes** or may represent metastasis.

Thyroid nodules occur in about 4% of the U.S. population. Most are associated with benign **processes** such as goiter or thyroiditis. The incidence of thyroid cancer is small, occurring in approximately...

...and surgery is indicated.(151) Fine needles (23 to 25 gauge) are recommended for thyroid **biopsy** because of the vascularity of the gland, but Taki(154) has used an 18-gauge, short-throw **biopsy** gun with no significant increase in complications. Use of the **biopsy** gun improved the diagnostic yield for **lesions** (is greater than) 10 mm. Reported complications from FNAB of the thyroid are infrequent and...

...local bleeding, vasovagal episodes and tracheal puncture.(152)

(Figures 14-15 ILLUSTRATION OMITTED)

Salivary gland **lesions** may be examined using IGPNB. Both major and minor glands are examined, although the parotid gland is **biopsied** most frequently because 80% of salivary gland malignancies occur there.(155) IGPNB of a salivary...

...Nodal involvement isolated to the lower third of the neck frequently is associated with primary **tumors** arising below the clavicle.(159)

When cervical nodes are not palpable, diagnostic imaging techniques, including...

...metastasis, but there are concerns regarding the diagnostic value of FNAB for lymphoma. Use of **biopsy** guns for PCNB of suspicious lymph nodes has proven superior to FNAB, with no increase...

...primarily concerned with changes in tissue architecture that may impact postsurgical histologic evaluation.(160)

Intracranial **lesions** can be assessed with IGPNB, commonly aided by stereotactic localization. Either FNAB or PCNB can be performed, depending on the type of **lesion** .(148) CT and MR are used for image guidance, with the choice depending on **lesion** visibility. For example, a **lesion** near the skull base may be obscured by beam-hardening artifacts on CT, so MR may demonstrate the **lesion** more clearly.(34) Guidance of the **biopsy** needle to the **lesion** frequently is accomplished with the aid of a stereotactic frame attached to the patient's head.(161) Frameless stereotactic **systems** also are under development. These **systems** direct the needle trajectory without a frame by monitoring the spatial location of the **biopsy** needle and overlaying the needle location on the image of the **lesion** .(40) Stereotactic **systems** have been designed for use with CT and MR, so these directed **biopsies** can be accomplished with the imaging technique that demonstrates the **lesion** most clearly.(149)

Stereotactically directed needle **biopsies** are performed when:

* The risk of a craniotomy is too great.
* The **lesion** is deep or near vital structures.
* Open surgical resection is not required for treatment.
* Identification of the **lesion** is desired before open surgery is performed.(148)

Reported complications from stereotactic needle **biopsy** include skin infection or dehiscence (splitting open) at the puncture site, varying

degrees of parenchymal hemorrhage, subtle neurologic deficits and fatal perioperative pulmonary embolism.(161)

Musculoskeletal

Musculoskeletal **lesions** are amenable to IGPNB, although its accuracy does not equal that of open, surgical **biopsy** . However, IGPNB is faster, safer, less ...the patient. The major disadvantage is the smaller amount of tissue retrieved compared with surgical **biopsy** .(162) The primary indication for musculoskeletal **biopsy** is to confirm metastasis from a known primary **tumor** . This is especially important when the **lesion** appears atypical for the type or stage of primary **tumor** , or when a **lesion** is found many years after treatment of the primary disease.(163)

The most common origins...

...lung, breast, prostate, kidney and thyroid, in that order.(159) When there are multiple primary **tumors** , IGPNB can aid in establishing the origin of the metastatic skeletal **lesions** . In addition, the IGPNB technique is helpful when bony **lesions** are suspicious for metastasis, but a primary **tumor** has not been found. Characterization of the malignant cells can aid in locating the primary **lesion** .(162) **Lesions** evident on radionuclide bone scans or MR, but not on CT or radiographs, may be sampled by IGPNB to differentiate a benign from malignant **process** .(164) In addition, metabolic diseases, infections in bone or joints, and other conditions such as...

...and sarcoidosis may be examined using IGPNB techniques.(162)

Contraindications to IGPNB of the musculoskeletal **system** include uncorrectable bleeding diatheses and infection in the tissues along the needle track. Sites considered inaccessible to IGPNB include sclerotic **lesions** in the anterior portion of the thoracic vertebral bodies next to the thoracic aorta, **lesions** of the odontoid **process** and **lesions** in the anterior arch of the first cervical vertebra.(164)

The most common imaging techniques...

...fluoroscopy and CT. Biplane fluoroscopy is recommended over conventional fluoroscopy to improve confirmation of needle **depth** . CT is used almost exclusively for the upper thoracic and cervical spine, as well as...

...with fluoroscopy, CT significantly improved the accuracy of IGPNB and permitted access to otherwise inaccessible **lesions** by allowing selection of a safe puncture route and identification of susceptible adjacent structures. Radionuclide scanning has been used as a PNB guidance technique for **lesions** not seen on other imaging exams.(167) However, the **biopsy** has been more successful when the **lesion** is visible with both nuclear medicine and radiography.(162)

Both fine and cutting needles are used for IGPNB in the musculoskeletal **system** . Needle choice depends on the nature and location of the **lesion** . Intact bony cortex overlying the **lesion** requires use of a bone-cutting needle, whereas an osteolytic **lesion** that has thinned or destroyed the cortex can be reached with an aspiration needle or...

...aspiration-cutting types.(163) TruCut needles have been used for soft-tissue masses, for osteolytic **lesions** extending beyond the cortex and for medullary **lesions** after cortical penetration by drill or bone-cutting needle.(164) An 18-gauge **biopsy** gun also has been used for medullary tissue sampling after cortical penetration.(168)

There are varieties of bone-cutting needle **systems** for penetrating the intact bony cortex. The common features are a trochar for penetration and...

...Craig and Ackermann).(164) The cutting cannulas have relatively large handles to facilitate trephine needle **rotation** and application of

pressure to the needle tip. (See Fig. 16.) Modifications and refinements continue to be made to these needle **systems** . Recently, Kruyt(170) developed a hybrid technique for musculoskeletal IGPNB using a power drill for cortical penetration, followed by a coaxial needle **system** consisting of an outer cannula and an inner, apple-corer shaped cutting needle with a side slot for specimen removal.

(Figure 16 ILLUSTRATION OMITTED)

Approach to the musculoskeletal **lesion** varies with location and intervening structures. Long bones of the extremities usually are approached anteriorly...

...for thin or flat bones, when a needle path traversing the long axis of the **lesion** would be safer and more productive. In addition, a less direct route may be desirable...

...the ilium, ischium and sacrum. (See Figs. 17 and 18.) In the spine, the spinous **processes** and laminae are **biopsied** from a posterior approach. A posterolateral approach is used for the transverse **processes** , pedicles, thoracic vertebral bodies and lumbar vertebral bodies. The first thoracic through fourth cervical vertebral...

...There have been few serious complications reported as a result of IGPNB in the musculoskeletal **system** . The most frequent complication is mild pain primarily related to inadequate anesthesia and negative pressure...

...ribs.(171) Hemorrhage may result from vascular injury, such as aortic puncture,(172) or from **biopsy** of vascular **lesions** .(162) Other extremely rare complications include foot drop, pneumonia, pneumoretroperitoneum, meningitis and death.(162) Overall, IGPNB has been found to be a safe and effective alternative to open, surgical **biopsy** for diagnosis of musculoskeletal **tumors** .

Conclusion

IGPNB has developed into a valuable tool for diagnosis of nonpalpable or deep-seated **lesions** that cannot be characterized definitively by their appearance on diagnostic images. Principal goals for the use of IGPNB are to decrease the need for surgical **biopsy** and to determine the nature of a **lesion** before nonsurgical treatment. This practice is driven by economic forces and the desire for minimally invasive diagnostic **procedures** .

IGPNB techniques are safe and effective alternatives to open surgical **biopsy** for diagnosis of a variety of **lesions** . Advances in **biopsy** needles and percutaneous **biopsy** **system** design have improved the safety and tissue yield of these **procedures** . Smaller **diameter** needles with improved tissue-cutting features allow multiple passes into a **lesion** with minimal complications and retrieval of sufficient material for both histologic and cytologic evaluation.

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Bruce W. Long, M.S...

...text. Transfer your responses to the answer sheet on page 382 and then follow the **directions** for submitting the answer sheet to the American Society of Radiologic Technologists. You also may...

...be received in the ASRT office on or before this date.

1. A percutaneous needle **biopsy** is considered to be a(n) -- **biopsy** .

   a. closed.
   b. open.
   c. surgical.
   d. wedge.

2. Into which 2 procedural areas is IGPNB divided?
   a. endobiliary brush **biopsy** and percutaneous core needle **biopsy** .
   b. transbronchial **bronchoscopic** **biopsy** and fine-needle aspiration **biopsy** .
   c. fine-needle aspiration **biopsy** and percutaneous core needle **biopsy** .
   d. transvenous needle **biopsy** and percutaneous core needle **biopsy** .

3. -- **biopsy** is used to collect cellular specimens from a **lesion** for cytologic and microbiologic analysis.
   a. Fine-needle aspiration.
   b. Percutaneous core needle.
   c. Percutaneous cutting needle.
   d. Core needle.

4. -- **biopsy** is performed when a tissue specimen is required for histologic analysis.
   a. Fine-needle aspiration.
   b. Endobiliary brush.
   c. Percutaneous core needle.
   d. **Endoscopic** fine-needle aspiration.

5. Techniques for PNB have been described in the literature since the ...bone-cutting needles is --.
   a. point.
   b. cannula.
   c. trephine.
   d. bevel.

18. A -- needle **system** consists of an outer needle **guide** (cannula) and an inner **biopsy** needle.
   a. single.
   b. coaxial.
   c. triaxial.
   d. side-by-side.

19. A -- cc syringe...

...having the patient:

a. sit upright in a chair.
b. stand.
c. lie with the **biopsy** site visible and free from pressure.
d. lie with the **biopsy** site dependent.

25. The gold standard for breast **biopsy** is:

a. FNAB.
b. PCNB.
c. surgical **biopsy** .
d. ductal brush **biopsy** .

26. BI-RADS stands for:

a. Breast Imaging Reporting and Data **System** .
b. Breast Imaging Review and Diagnostic **System** .
c. Bureau Internationale Radiologic Diagnostic Societe.
d. Bivalent Integrated Reporting and Data **System** .

27. When using **directional** , vacuum-assisted breast **biopsy** **systems** , retrieval of 5 specimens has been recommended to ensure a high degree of accuracy, but -- or more specimens may be required if calcifications are present in the **lesion** .

a. 7.
b. 8.
c. 9.
d. 10.

28. The "1-second technique" for percutaneous liver **biopsy** was developed in 1958 by:

a. Mengini.
b. Madayag.
c. Mueller.
d. Mendelson.

29. According to Lees,(129) the -- is the most dangerous abdominal organ to **biopsy** .

a. liver.
b. pancreas.
c. kidney.
d. stomach.

30. Which of the following is an...

...adrenal mass.

c. small ((is less than) 5 cm) adrenal mass and a primary lung **tumor** .
d. MR results consistent with nonfunctioning adenoma.

31. FNAB is used successfully for lymph node **biopsy** . However, PCNB is often necessary to provide sufficient tissue for histologic subtyping of:

a. sarcoma...

...thyroid.

b. lung.
c. prostate.
d. kidney.

34. Which of the following is a bone **biopsy** needle?

a. Chiba.
b. Greene.
c. Ackermann.
d. Abrams.

Reference No. DRI0000003

DESCRIPTORS: **Biopsy** , Needle...
20000301

29/5,K/35 (Item 15 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01873367 SUPPLIER NUMBER: 57892911 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Repeated Ultrasonically Guided Needle Biopsy **of Small Subpleural Nodules(*).**
Obata, Ken'ichi; Ueki, Jun; Dambara, Takashi; Fukuchi, Yoshinosuke
Chest, 116, 5, 1320
Nov,
1999
PUBLICATION FORMAT: Magazine/Journal; Refereed ISSN: 0012-3692
LANGUAGE: English RECORD TYPE: Fulltext TARGET AUDIENCE: Professional
WORD COUNT: 3543 LINE COUNT: 00303

DESCRIPTORS: Lungs-- **Biopsy** ; **Biopsy** , Needle--Diagnostic use; Lung diseases--Diagnosis
FILE SEGMENT: HI File 149

Repeated Ultrasonically Guided Needle Biopsy **of Small Subpleural Nodules(*)....**

TEXT:

Study objective: To detect the significance of repeated ultrasonically guided needle **biopsy** (UGNB) for the diagnosis of nodular **lesions** (is less than or equal to) 2 cm in **diameter** .
... outpatients, and inpatients of the respiratory department.

Patients: One hundred seven cases with small modular **lesions** (is less than or equal to) 2 cm in **diameter** in contact with the pleura. Sixty-two of 107 cases were malignant, and the others were benign diseases.

Results: Initial UGNB identified 56% (35/62) of the malignant **lesions** and 16% (7/45) of the benign **lesions** , ie, 39% (42/107) of the total. In 35 of 65 cases that were not...

...reexamined. Furthermore, 51 of 65 patients with negative findings on the initial UGNB underwent fiberoptic **bronchoscopy** . The resulting diagnostic yields were 22% (5/23) from the malignant **lesions** and 18% (5/28) from the benign **lesions** , 20% (10/51) in total. Thus, among the malignant cases, the repetition of UGNB increased the definitive diagnostic yield from 56% (the initial UGNB) to 77%. In these small **tumors** , no serious complications were caused by the **procedure** .

Conclusions: UGNB should be performed twice for a definitive diagnosis of small subpleural nodules before deciding on surgical **biopsy** or follow-up. (CHEST 1999; 116:1320-1324)

Key words: small pulmonary nodule; transthoracic needle **biopsy** ; ultrasound

Abbreviations: FBS = fiberoptic **bronchoscopy** ; UGNB = ultrasonically **guided** needle **biopsy**

The widespread use of CT has increased the detection of small **lesions** in the lung field. It is not easy to diagnose these **lesions** based only on the CT findings, and specimens obtained directly from the **lesions** are essential for definitive diagnosis.(1) The pulmonary nonsurgical approaches to obtain small specimens directly...

...contact with the pleura without necessitating exposure to ionizing

radiation. We employ ultrasonically guided needle **biopsy** (UGNB) as the first **method** of choice to obtain specimens from the **lesion** , and the usefulness of this technique has been widely acknowledge. (2-4) In particular, since...

...small lung cancer, it is necessary to improve the diagnostic yield in cases with small **lesions** . In this study, the subjects were cases with subpleural nodules in which we had performed...

...the definitive diagnosis of small nodules ((is less than or equal to) 2 cm in **diameter**) in which negative diagnoses were initially obtained.

MATERIALS AND **METHODS**

This study encompassed a total of 335 cases with subpleural nodules in which UGNB was...

...chest radiographs. The relationship between the frequency of malignant disease and the size of the **lesion** was studied in the 335 cases. Next, we focused on 107 cases (62 of malignant...

...benign disease) that presented nodular shadows (is less than or equal to) 2 cm in **diameter** . The diagnostic yields of UGNB and fiberoptic **bronchoscopy** (FBS) were surveyed, and a similar survey of the 30 cases of malignant nodular shadows (is less than or equal to) 1.5 cm in longest **diameter** was performed.

The equipment used in this study consisted of ultrasound units (SSA-90A and...

...MHz linear array transducer (GCE-406M; Toshiba), and a metallic needle (0.8-mm inner **diameter** , 1.0-mm outer **diameter** , and 150 mm long; Takei Medical & Optical; Tokyo, Japan) for UGNB. First, the puncture site was verified on the **ultrasound** **image** with the **patient** and operator in comfortable positions. After local anesthesia with 0.5% procaine hydrochloride, the needle...

...ultrasound image guidance on a TV monitor; while observing the tip of the needle, aspiration **biopsy** was carried out using a one-hand grip aspirator. The puncture of the nodule by...

...was repeated immediately once or twice, and the entire series was considered as a single **procedure** . A specific finding obtained from the cytologic or bacteriologic testing examinations was taken as positive. Before the **procedure** , allergic reactions to local anesthetics and tendency to bleed were checked. UGNB was performed in...

...performed as follows: after the induction of local anesthesia with 2% lidocaine, a 6-mm **diameter** fiberoptic **bronchoscope** (model BF-10; Olympus Optical; Tokyo, Japan) was introduced through the mouth without endotracheal intubation, and forceps **biopsy** , brushing, and lavage of the **lesion** were performed under radiograph fluoroscopic guidance.

When a diagnosis was not obtained by the initial UGNB **procedure** , a second UGNB was carried out within 1 month of the first **procedure** . A **bronchoscopic** examination was usually performed between these two UGNB **procedures** . When no positive findings emerged from all of the above examinations, a choice was made between surgical **biopsy** and further follow-up observations.

For comparison of the diagnostic yields, classified by **lesion** size and by examination **method** , and for testing for significant differences in the frequency of complications, the (chi square) test...

...2. Of 107 small nodules (32%) (is less than or equal to) 2 cm in

diameter , 62 were malignant (58%). Among 87 cases of nodules between 1.1 cm and 2.0 cm in **diameter** , 53 cases (61%) were malignant, whereas 9 cases (45%) were malignant of the 20 cases that were (is less than or equal to) 1.0 cm in **diameter** . The frequency of malignancy tended to be lower in the smaller nodules.

(Figure 2 ILLUSTRATION...

...cases with negative findings on the initial UGNB, yielded definitive diagnoses in 17 cases (49%). **Bronchoscopy** that was performed in 51 of 65 cases in which the initial UGNB finding was...

...diagnose malignancy in 77% of cases (48/62) by combining the first and second UGNB **procedures** (Tables 1, 2). Also, **bronchoscopy** yielded definitive diagnoses in 22% of malignant cases (5/23).

Table 1--Diagnostic Yields of **Biopsy** From Small Subpleural Nodules ((is less than or equal to) 2 cm)(*)

Procedure	Diagnostic Yield (n = 107)	Malignant (n = 62)	Benign (n = 45)
First UGNB	42/107 (39)	35/62 (65)	7...

...Malignant Nodules From 1.6 to 2 cm and 1.5 cm or Less in **Diameter** (*)

	Diagnostic Yield	
	(is less than or equal to) 2 cm	1.6 to 2.0...

...the second UGNB. Thus, repeated UGNB diagnosed an overall total of 11 benign cases (24%). **Bronchoscopy** in 28 of 38 cases with negative findings in the first UGNB yielded diagnoses in 5 cases (18%). All 16 benign **lesions** that were diagnosed by UGNB or **bronchoscopy** were mycobacteriosis. We performed a total of 142 initial and second UGNB **procedures** . In 4 of 142 **procedures** , aspiration was repeated immediately, once because of a lack of tissue fragments in the washings...

...carcinoma up to 2 cm in longest dimension and up to 1.5 cm in **diameter** is shown in Table 2. The yields of definitive diagnoses in 30 cases of pulmonary carcinoma nodules (is less than or equal to) 1.5 cm in **diameter** were 47% (14/30) on the first UGNB and 67% (8/12) on the second...
...nodules, 107 cases of small nodules (is less than or equal to) 2 cm in **diameter** , and 62 cases of small pulmonary carcinoma of (is less than or equal to) 2 cm in **diameter** . The incidence of complications showed no significant difference between for the total of 335 cases and for small nodules (is less than or equal to) 2 cm in **diameter** , and there was no significant difference in the data for malignant or benign nodules. These ...

...Data are presented as No. (%)

((dagger)) (is less than or equal to) 2 cm in **diameter** .

DISCUSSION

Opportunities to discover small **lesions** in the lung field have increased with the growing frequency of CT examinations of the chest. Noninvasive approaches have been tried in order to distinguish between benign and malignant small **lesions** by techniques such as high-resolution CT,(5,6) three-dimensional CT,(7) and nuclear...

...satisfactory. There has been a recent trend toward the increased use of thoracoscopy as a **method** of obtaining specimens directly from these small **lesions** . However, since these thoracoscopic lung **biopsies** (9) have to be conducted under general anesthesia, less invasive **procedures** such as **bronchoscopic** examination and percutaneous **biopsy** are more frequently

performed before surgical **biopsy** .

Bronchoscopy has contributed greatly to the diagnosis and evaluation of lung cancer originating from the bronchus cm in **diameter**), while varying slightly among institutions, is hardly in the satisfactory range.(1,10,11) In pulmonary adenocarcinoma arising in the peripheral lung parenchyma, the smaller that the primary **lesion** is, the lower the frequency of advanced stage.(12) To improve the patient's prognosis, therefore, it appears necessary to differentiate between benign and malignant disease while the **lesion** is still small. Many institutions have consequently turned to percutaneous **biopsy** techniques using fluoroscopic(13-15) or CT guidance.(16,17)

The small nodules ((is less than or equal to) 2 cm in **diameter**) in this report accounted for approximately one third of all subpleural nodules (335 cases), and some 60% of them were malignant. Moreover, 20% of the **lesions** were (is less than or equal to) 1.5 cm in **diameter** . It is foreseeable that to increase the diagnostic yield for small subpleural **lesions** , a percutaneous approach will become more of a routine **procedure** than **bronchoscopic** examinations.(18) In the present study, the results for the first UGNB yielded 42 diagnoses...

...first UGNB, it is difficult to decide whether to proceed by carrying out a surgical **biopsy** or a **bronchoscopic** examination, or to repeat the percutaneous **biopsy** .

The likelihood of a malignancy is relatively low with smaller-sized **lesions** , and nearly half of the nodular shadows (is less than or equal to) 2 cm in **diameter** in our series turned out to be benign **lesions** (Fig 2). When it is not possible to judge whether these small **lesions** are malignant or benign after the first noninvasive **procedures** , it would be too aggressive to carry out surgical **biopsies** in all such cases, because about half of them will be benign **lesions** quite adequately treatable by conservative treatment, including follow-up studies.

In the present study, the diagnostic yield obtained by **bronchoscopic** examination of small subpleural nodules (is less than or equal to) 2 cm in **diameter** was significantly lower than that for the second UGNB (p (less than) 0.01). It...

...suggested that the diagnostic yield would be improved by repetition of UGNB if the initial **procedure** finding is negative. In particular, when looking at malignant cases, the diagnostic yield of initial...

...cases with negative findings on the initial UGNB, the overall diagnostic yield for small malignant **tumors** increased to 77%. Furthermore, in the present study, since not all of the cases with...
...positive rate above 77%.

On the basis of a report that pulmonary carcinomas with a **diameter** (is less than or equal to) 1.5 cm have fewer distant metastases,(19) UGNB is desirable for such **lesions** . The present results of UGNB suggested that there was no significant difference between the diagnostic...

...up to 1.5 cm and from 1.6 cm to 2.0 cm in **diameter** , and the diagnostic yield in the former **lesions** was improved by the repetition of UGNB.

Among the cases that were analyzed in this...

...mycobacteriosis, the diagnostic yield may be improved by combined use of the polymerase chain reaction **method** in order to investigate the presence of tubercle bacilli.(20)

In the widely used percutaneous aspiration **biopsy - guided** fluoroscopy and CT **method** , pneumothorax is reported in 6 to 33% of cases, bloody sputum in 5 to 19%, and intrapulmonary hemorrhage in 21 to 35%.(1,13-17) Moreover, in **bronchoscopic** **biopsies** , pneumothorax occurs

in approximately 5% of cases, and bloody sputum or hemoptysis occurs in about...

...include pneumothorax, bloody sputum, hemothorax, and the vasovagal reflex. In the present series of small **lesions** , such complications were mild in degree and low in incidence (pneumothorax, 3%; bloody sputum, 4%), but their incidence did not differ according to **lesion** size or to whether the **lesion** was malignant or benign. The small nodular shadows are in contact with the pleura, and...

...the low frequency of complications and the mild complications, repetition of UGNB is an acceptable **procedure** .

Moreover, 39 of 62 patients (63%) in this study who had small carcinomatous **tumors** were (greater than) 65 years old. This fact suggests that as long as the patients...

...maintain the desired posture and hold their breath, thus permitting a clear depiction of the **lesion** on the ultrasound image, there is no age-related limitation on the UGNB **procedure** . The UGNB can be carried out repeatedly in cases with small nodules on an outpatient basis. In the coming years, the elderly, who have more malignant **tumors** , will increase in number, and the UGNB is safe technique with great clinical advantage in ...

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...DESCRIPTORS: **Biopsy** ; ...

... **Biopsy** , Needle
19991101

29/5,K/39 (Item 19 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01813499 SUPPLIER NUMBER: 53545116 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Preoperative Diagnosis With Video-Assisted Thoracoscopy With Miniaturized Endoscopes **in General Thoracic Surgery(*): A Preliminary Study.**
Nakamoto, Kembu; Maeda, Masazumi; Okamoto, Taku; Kameyama, Kohtaro; Sugita, Ayanori; Hayashi, Eiichi
Chest, 114, 6, 1749(1)
Dec,
1998
PUBLICATION FORMAT: Magazine/Journal; Refereed ISSN: 0012-3692
LANGUAGE: English RECORD TYPE: Fulltext TARGET AUDIENCE: Professional
WORD COUNT: 4302 LINE COUNT: 00381

DESCRIPTORS: Chest--Surgery; Thoracoscopy--Technique
FILE SEGMENT: HI File 149

Preoperative Diagnosis With Video-Assisted Thoracoscopy With Miniaturized Endoscopes **in General Thoracic Surgery(*): A Preliminary Study.**
Video-assisted thoracoscopy using a miniaturized **endoscope** (mini-VAT) was applied for preoperative diagnosis in general thoracic surgery. Thirty-one patients, including...
...indeterminate pulmonary nodule and 4 with suspected pleural involvement of lung cancer or metastatic pleural **tumor** , underwent mini-VAT. As a pilot study, 14 of the former 27 patients underwent mini...

...anesthesia. Solid scopes of three different sizes, 0.9, 1.9, or 4.0 mm **diameter** , were used. An artificial pneumothorax for scope introduction was produced by needle thoracentesis under atmospheric pressure. Automatic cutting needle **biopsy** was used for tissue sampling. In the pilot study group, mini-VAT with a 4...

...visibility and diagnostic sensitivity of 100%. This study group showed the diagnostic sensitivity of needle **biopsy** for pulmonary nodule to be 100%. Hemorrhages and air leaks at **biopsy** sites were sealed with blood coagulation in a short time. In the prospective study group...

...failure of mini-VAT with the use of local anesthesia were cough reflex

during needle **biopsy** and incomplete lung collapse for deeply located target in two cases. The adverse effects of...

...only local anesthesia required no chest tube drainage. Mini-VAT is a simple, minimally invasive **procedure** suitable as a preoperative examination technique for histologic diagnosis, evaluation of disease progression, and selection of strategy in thoracic surgery.

(CHEST 1998; 114:1749-1755)

Key words: cutting needle **biopsy** ; mini thoracoscopy; preoperative examination; thoracic surgery

Abbreviations: VATS = video-assisted thoracoscopic surgery; mini-VAT = video-assisted thoracoscopy using a miniaturized **endoscope**

The worldwide spread of video-assisted thoracoscopic surgery (VATS) has extended both therapeutic and diagnostic...

...lung diseases, and of other conditions(3), as an alternative to exploratory thoracotomy. Progression of **endoscopic** surgery in other fields is facilitating the development of miniaturized scopes and related instruments.(4) Also, a simple and safe core **biopsy** needle has been developed for obtaining sufficient tissue specimens for pathologic diagnosis of liver, pancreas...

...kidney diseases.(5) If these miniaturized scopes and optional instruments were applied in VATS, the **procedure** could become simpler and less invasive. Thus, video-assisted thoracoscopy using a miniaturized **endoscope** (mini-VAT) could be an optional diagnostic strategy in thoracic surgery.

This study describes and...
...of mini-VAT with the patient receiving local anesthesia as a simplified and minimally invasive **procedure** for preoperative diagnosis and evaluation in general thoracic surgery.

MATERIALS AND **METHODS**

Thirty-one patients underwent mini-VAT from August 1996 through December 1997. All patients were...

...before mini-VAT was used. Informed consent was obtained from all patients. The mini-VAT **procedure** was performed with patients receiving general or local anesthesia.

General Anesthesia Group

As a pilot study, mini-VAT was performed in 14 patients who received general anesthesia to establish the **method** of scope introduction to the pleural space and to cheek the application of the cutting needle **biopsy** for safe and sufficient tissue sampling. The patients ranged in age from 20 to 84...

...more than 30 mm. Five patients of this group underwent quick pathologic diagnosis with needle **biopsied** specimens as an alternative to wedge resection. In all 14 patients, needle **biopsy** was followed immediately by conventional thoracotomy or wedge resection using an endostapler with the mini-VAT **procedure** . The pathologic diagnosis with needle **biopsy** was made independently from that of the resected sample.

Local Anesthesia Group

As a prospective...

...VAT

Solid scopes of 3 different sizes were used; 1 was 0.9 mm in **diameter** (MS-611; Medical Science; Tokyo, Japan), another was 1.9 mm in **diameter** (Mini Site Laparoscope; Auto Suture Comp; Norwalk, CT), and a third was 4 mm in **diameter** (Telescope A 7801; Olympus; Tokyo, Japan; or Hopkins II; Karl Storz CMBH; Tuttlingen, Germany). A...

...a puncture port for the 0.9-mm scope. Metallic trocars of 2 mm in **diameter** for the 1.9-mm scope and of 5 mm in **diameter** for the 4-mm scope were used as puncture ports for mini-VAT through a skin incision slightly smaller than the **diameter** of each trocar.

Mini-VAT **Procedure**

The general anesthesia group had one lung anesthetized with a double-lumen endotracheal tube or bronchial blocker during the **procedure** (Fig 1). In the local anesthesia group, an oxygen mask was used during the **procedure** . Pulse oximetry and ECG were recorded for monitoring in the local anesthesia group. Patients in...

...pleura after detecting the upper edge of the costal rib or accessed to the same **distance** of chest wall as measured on the chest CT scan. A 14-gauge angiocatheter connected...

...the same site after removing the plastic cannula, and a thoracoscope connected to a video **system** was **inserted** via the trocar to observe the target. When lung collapse was not enough for observation...

...the small chest hole (Fig 2) inserted from an additional port, were used. An automatic **biopsy** needle (Tru-Cut needle 18G Monopty; C.R. Bard; Covington, KY) inserted through a 14-gauge angiocatheter was used as a percutaneous **biopsy** needle to obtain tissue specimens of the target. Patients held their breath during the firing of the **biopsy** device. The **biopsy** needle was fired so as to avoid hitting the major bronchi or vessels which had been detected earlier with a **preoperative** chest **CT** scan. **Biopsy** specimens were floated in saline solution and checked with a loupe to verify if **tumorous** tissue was obtained. If **tumorous** tissue was not detected, the needle **biopsy** was tried again. After the **lesions** from which **biopsy** specimens were removed were sealed with blood coagulation, the lung was reinflated by withdrawal of...

...anesthesia had a chest x-ray film taken at the end of the mini-VAT **procedure** . The duration of the mini-VAT **procedure** was up to 1 h. **Biopsy** specimens were stained with hematoxylin-eosin.

(Figure 2 ILLUSTRATION OMITTED)

RESULTS

General Anesthesia Group

Needle...

...needle tip in any of the 14 cases. A scope of 4.0 mm in **diameter** was used in 10 patients and that of 0.9 mm in **diameter** was used in 4 patients. In all 10 of the former cases, the target location was detected using the 4.0-mm scope with the mini-VAT **procedure** , but in 2 of the latter 4 cases, the target was not detected with the...

...poor visibility (Table 1). The 12 patients in whom the target was detected underwent needle **biopsy** for indeterminate pulmonary nodule. In these patients the target was accurately hit by the **biopsy** needle, and a definitive diagnosis was obtained (Table 2). Five of these 12 patients underwent needle **biopsy** during the operation for quick pathologic diagnosis. Pathologic diagnoses from the needle **biopsy** specimen and the resected sample obtained during the subsequent VATS or thoracotomy were the same...

...with organized pneumonitis, 1 with tuberculoma, 1 with pulmonary hematoma, and 2 with metastatic lung **tumor** . In one patient, the diagnosis was pulmonary hematoma Milch was suspected to be a posterior mediastinal **tumor** accompanied by extrapleural signs on the chest CT scan taken before the mini-VAT **procedure** . All sites from which **biopsy** specimens were removed in the 12 patients showed complete hemostasis and complete sealing

against air...

...50% for the 0.9-mm scope (Table 1). The thoracoscopy with the 4-mm **diameter** scope provided excellent visibility (Fig 1). The overall diagnostic accuracy of mini-VAT in all patients receiving general anesthesia was 86% (Table 1). The diagnostic sensitivity of needle **biopsy** for pulmonary nodule using miniVAT, excluding 2 patients in whom the target was not detected...10/10 (100%) 2/4 (50%) 12/14 (86%)

Table 2--Diagnostic Sensitivity of Needle **Biopsy** for Pulmonary Nodule According to Nodule Size (General Anesthesia Group)

	Nodule **Diameter**		
Patients	< 10 mm	< 20 mm	< 30 mm
Patients undergoing needle **biopsy**	1	5	6
Patients diagnosed	1	5	6
Sensitivity	1/1 (100%)	5/5 (100%)	6/6 (100%)

Patients	(is greater than or equal to) 30 mm	Total
Patients undergoing needle **biopsy**	...(*)	12
Patients diagnosed	...(*)	12
Sensitivity		12/12 (100%)

(*) No cases reported.

Local Anesthesia Group

Seventeen patients underwent mini-VAT while receiving local anesthesia. A scope of 4.0 mm in **diameter** was used in 14 patients and of 1.9 mm in **diameter** was used in 3. Fourteen patients underwent mini-VAT for indeterminate pulmonary nodule and 3...

...made of extrapulmonary nodule, which was a pleural metastasis from oral cancer detected by needle **biopsy** . The remaining 13 patients with a pulmonary nodule underwent needle **biopsy** . In 2 of these 13 patients, the target was missed because of a cough reflex...

...when using a 4.0-mm scope without pleural anesthesia and deep location of the **tumor** in the other when using a 1.9-mm scope without palpation probe or lung forceps. These two **patients** refused further examination. **Pathologic** diagnosis with needle **biopsy** in the remaining 11 patients was as follows: 4 with lung cancer, 5 with organized...

...pulmonary hilum was used to prevent the occurrence of adverse reflexes during the mini-VAT **procedure** . Two of the three patients who were suspected of having pleural progression of lung cancer...

...only thoracoscopic observation. The third patient had pleural dissemination of lung cancer and underwent needle **biopsy** . Subsequent treatments in the local anesthesia group excluding the two patients who refused further examination...

...50% for the 1.9-mm scope (Table 3). The overall diagnostic sensitivity of needle **biopsy** for a pulmonary nodule was 85%, and that for nodule size of less than 30...

...their respiration was allowed to stabilize. The lung was then again deflated, and a needle **biopsy** was performed. Their chest x-ray films at the end of mini-VAT showed partial...

...pulmonary nodule; PD = pleural disease with suspected pleural involvement of lung cancer or metastatic pleural **tumor** .

Table 4--Diagnostic Sensitivity of Needle **Biopsy** for Pulmonary Nodule According to Nodule 2/3 (67%11/13 (85%) (Local Anesthesia Group)

	Nodule **Diameter** , mm		
Patients	< 10	< 20	< 30
Patients undergoing needle **biopsy**	3(*)	4	3
Patients diagnosed	2	4	3
Sensitivity	2/3 (67%)	4/4 (100%)	3/3 (100%)
		9/10 (90%)	

	Nodule **Diameter** , mm	
Patients	(is greater than or equal to) 30	Total
Patients undergoing needle **biopsy**	3((dagger))	13
		11
Patients diagnosed	2	
Sensitivity	2/3(67%)	11/13 (85%)

(*) One of these cases...

...receiving local anesthesia is applied in the diagnosis of pleural diseases with effusions.(2) This **procedure** is not applied for intrapulmonary diseases because **biopsy** requires wedge resection with endostaplers under unilateral ventilation. Development and use of miniaturized **endoscopes** , **biopsy** needle devices, and optional instruments can make video-assisted thoracoscopy simpler and less invasive. In the present study, mini-VAT was used and the possibility of using this **procedure** with patients receiving local anesthesia ...and has a cosmetic advantage (Fig 3).

(Figure 3 ILLUSTRATION OMITTED)

A cutting needle lung **biopsy** is generally ill advised because of persistent air leakage from the **biopsy** site,(1) fear of cancer cell implantation (though with less than a 1% occurrence),(7...

...air leakage were minimal complications as long as the patient had no coagulopathy or the **biopsy** site of the lung had no bullous changes. The size of needle used in this study is the same as that used in CT-guided needle **biopsy** , and the risk of cancer cell implantation also may be the same. Seeding of cancer...

...a 14-gauge angiocatheter. In a review of two fatal hemorrhages developing after cutting needle **biopsy** , both cases occurred with a Silverman needle.(9) This needle curls lung parenchyma in its split forceps and tears the tissue wider than its **diameter** , causing massive hemorrhage. Also, a **tumor** in the lung parenchyma is easily moved by the needle tip in a manual **biopsy** and a large enough tissue specimen may not be obtained.(5) Automatic **biopsy** with the Tru-Cut needle used in the present study provided a large enough tissue...

...The fine Tru-Cut needle is fired by a springloaded device and instantaneously penetrates the **tumor** core.(5) Tissue obtained by

automatic needle **biopsy** as an alternative to wedge resection yields specimens for frozen sections and rapid pathologic diagnosis...

...has been reported to be 10 to 60% and that of CT-guided aspiration needle **biopsy** to be 80 to 90%.(10) However, the diagnostic accuracy of CT-guided needle **biopsy** decreases as the nodule size becomes smaller. When the nodule size is less than 30 mm, its success rate is 50%.(11) Automatic needle **biopsy** using mini-VAT can accurately hit a very small nodule if it is located in...

...by pleural changes. In the present series, the smallest pulmonary nodule was 5 mm in **diameter** , and it was diagnosed accurately. In the present study, the diagnostic sensitivity for a pulmonary...

...local anesthesia was 90%.

Cytologic examination of very small specimens obtained by CT-guided needle **biopsy** often fails to provide precise information about cell type and **tumor** origin.(1) Another limitation of CT-guided needle **biopsy** is for nonspecific benign diagnosis. Nodule palpation using mini-VAT makes possible the diagnosis of a benign pulmonary nodule without **tumor** building, such as organized pneumonitis. Mini-VAT may be an optional strategy if **bronchoscopy** or CT- **guided** needle aspiration fails to give a definitive or histologic diagnosis of a pulmonary nodule.

Preoperative...

...cancer progression to the pleura and for selection of treatment. One case of metastatic pleural **tumor** and another of pulmonary hematoma showed that mini-VAT is useful for differentiation between intra...
...to be inferior to that with patients receiving general anesthesia. Adverse reflex during the needle **biopsy** and an incomplete lung collapse for a deeply located target were the causes of missed...

...periods. Paradoxic respiration and mediastinal shift(12) limit the period of time during which this **procedure** can be applied, especially in overweight patients or in those with low cardiopulmonary function. This...

...shows that mini-VAT with patients receiving local anesthesia is a simplified and minimally invasive **procedure** if performed within a brief period of less than 1 h and has the potential for further application as a diagnostic strategy.

CONCLUSION

Mini-VAT is a safe, simple **procedure** for preoperative diagnosis and evaluation in general thoracic surgery. Further developments of the scope and related instruments may improve the diagnostic sensitivity of this **procedure** and extend its applications.

ACKNOWLEDGMENT: We thank M. Mitani for preparation of this manuscript.

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19981200

29/5,K/40 (Item 20 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01806837 SUPPLIER NUMBER: 21259695 (USE FORMAT 7 OR 9 FOR FULL TEXT)
The virtual surgeon.
Satava, Richard M.
The Sciences, v38, n6, p34(6)
Nov-Dec,
1998
PUBLICATION FORMAT: Magazine/Journal; Refereed ISSN: 0036-861X
LANGUAGE: English RECORD TYPE: Fulltext; Abstract TARGET AUDIENCE: Academic
WORD COUNT: 4066 LINE COUNT: 00332

ABSTRACT: Technological innovations relating to medical surgery are moving at a rapid pace. The heart-lung machine made it possible in 1952 to perform an open-heart surgery. In the 1990s, surgeons are using computer technology such as three-dimensional images, robotic manipulators, and computing devices to create e new framework for carrying out surgical **procedures** .

SPECIAL FEATURES: illustration; photograph
DESCRIPTORS: Operations, Surgical--Innovations; Surgeons--Science and technology policy; Technology--Health aspects
FILE SEGMENT: AI File 88
...ABSTRACT: images, robotic manipulators, and computing devices to create e new framework for carrying out surgical **procedures** .
... artificial circulation within the largest blood vessels while the heart was temporarily stopped for the **operation** . In the 1960s flexible **endoscopes** were developed, which incorporated fiber optics to enable the surgeon to see inside a hollow...

...three-dimensional images, and will even provide the sensation of touching those images. Stereo imaging **systems** , computers and robotic **manipulators** will combine to create a new framework for carrying out surgical **procedures** . And the benefits of that framework will be felt beyond the operating room. Escaping the confines of geography, the surgeon of the future will routinely use two-way audio-visual **systems** to **guide** students or consult with colleagues.
Such advances already exist outside the realm of mere imagination...

...a computerized three-dimensional model of the optic nerve that can be studied from any **angle** . In 1994 the radiologists Ron Kinkinis and Ferenc A. Jolesz and the neurosurgeon Peter M...

...live video image. With that technology fine surgeons can pinpoint the position of a brain **tumor** to within 0.5 millimeter--an unprecedented precision. And in 1997 the surgeons Jacques Himpens...

...medicine in general--is not in blood and guts, but in bits and bytes.

NO **PROCEDURE** NOW IN USE BETTER SHOWS the way to the coming revolution in surgery than laparoscopy...

...laparoscope is a stainless steel tube, about a foot long and a half inch in **diameter** , with an eyepiece on one end. The surgeon inserts the tube through a small abdominal...

...to hold the laparoscope with one hand, leaving only one hand free to take a **biopsy** or make a repair. That problem was solved recently when miniature video cameras were incorporated...perceptual understanding. Moreover, the laparoscopic instruments are awkward and counterintuitive. Imagine trying to eat without **bending** your wrist, or think about how limited your dexterity is when you are pulling a...

...of in front of the surgeon. That means the surgeon is not looking in the **direction** of his or her hands while performing the operation. The natural coordination of visual perception...

...all four of those difficulties virtual reality can play a corrective role, and several new **systems** for telesurgery have already been designed to address the problems. Such **systems** promise to retain the benefits of minimally invasive surgery while restoring to the surgeon the intuitive, 3-D experience of open surgery.

Among those **systems** are ones designed by Philip S. Green of SRI International in Menlo Park, California; by...

...in Karlsruhe, Germany; and by Ian W. Hunter of the Massachusetts Institute of Technology. Each **system** takes a somewhat different approach to improving laparoscopic surgery; what they all have in common...

...the feeling of directly perforating surgery on the patient. In the SRI and Computer Motion **systems** , the surgeon at the console holds instrument handles that look and feel like the real surgical instruments. An **image** from the **patient** is projected in such a way that the surgeon can look downward (as if looking...

...to the surgeon without exposing the patient to the risks of traditional surgery.

The SRI **system** (now licensed to Intuitive Surgical, Inc., of Mountain View, California) was the one used by...
...who performed the successful human gallbladder operation I mentioned earlier. In initial animal studies, that **system** has also proved capable of performing numerous other common surgical **procedures** , including gastric resection (removal of part of the stomach), splenectomy (removal of the spleen) and...

...chest human telesurgery heart operation, at Broussais Hospital in Paris. Using the SRI/Intuitive Surgical **system** , the surgeons were able to open a blocked artery by snipping out the diseased part...

...In short, they performed a coronary bypass operation using minimally invasive techniques.

In the Karlsruhe **system** the surgeon sits in a cockpitlike console, with a bank of video screens in front...

...naturalistic result is enhanced by the bank of monitors, which shows the surgeon different internal **images** of the **patient** as well as a panoramic view of the operating room. Thus, rather than giving the...

...he or she is standing outside the patient and looking down into the

abdomen, the **system** gives the perception that the surgeon is holding the handles of the instruments while positioned practically inside the abdomen.

Indeed, several of the telesurgery **systems** are being developed to enhance the surgeon's experience beyond normal human capabilities. Hunter, for instance, has designed a **system** to improve dexterity in ophthalmologic surgery. One of the difficulties of modern retinal surgery is...

...stationary, but instead has a natural motion of 200 cycles a second.

The Hunter telesurgery **system** offers a solution to those problems. First, it tracks the motion of the patient's...

...a platform-mounted camera, so that the eye appears stationary on the video display. The **system** can also scale down the motion of the surgeon's hand by a hundredfold: if...

...vessel can be magnified to the size of a finger. Finally, through sophisticated digital signal **processing** and filtering techniques, the computer interface can remove the normal tremor of the surgeon's hand. By combining all those techniques, the **system** can enable the surgeon to position a laser to within ten microns of its target--making it ten times more accurate than the unaided hand.

All the new telesurgery **systems** incorporate simple sensors that can convey to the surgeon a sense of pressure, or resistance...
...touch will eventually come to play a larger role in creating the virtual experience.

TELESURGERY **SYSTEMS** were initially developed to enhance the surgeon's dexterity. The surgeon was to sit near...

...the gallbladder operation in Belgium were done.) But the use of computers and other electronic **systems** to improve dexterity created an unintended consequence: the possibility of remote surgery. Once motion is ...

...computer, the possibility exists to transmit those signals to distant sites.

That said, all the **systems** under development use either a direct connection, via electronic cable, or a wireless link over a very short **distance** . It remains for the future to realize the dream of providing remote expert surgical capabilities...

...lack such care.

For now, any remote surgery will take place only over fairly short **distances** . The reason is that long- **distance** transmission via satellite communication creates a lag in the signals. Geosynchronous satellites hover about 22...
...earth; at that height, it takes longer than 1.5 seconds for them to receive, **process** and bounce back signals. Such a lag time creates a barrier for telesurgery, because the...

...extensive training.

In addition, when lags of 200 milliseconds or more come into play, telesurgical **systems** become unstable and tend to crash. Hence, at least for the immediate future, telesurgical **systems** will probably be usable only where the lag time is less than 200 milliseconds. That organs to images, thereby gaining a fuller understanding of **body** **parts** and their interrelations.

Several other virtual worlds have been developed to demonstrate basic anatomy and...

...simulator also incorporated several virtual laparoscopic tools, which enabled the student or surgeon to practice **endoscopic** surgical techniques.

Another virtual world is the limb trauma simulator, developed in 1994 by the...

...and possibilities of virtual reality. At the University of California, San Diego, for instance, the **instructional** developer Helene M. Hoffman has created a software application to teach anatomy that combines **virtual** reality with **two - dimensional** multimedia educational resources. The hybrid **system** enables students to learn anatomy and also to see related studies in pathology, histology and...

...tract in 3-D, and also see images of an ulcer and videos of a **biopsy** being performed on the ulcer.

When such anatomical simulators are augmented with information from a ...

...patient's brain to be operated on, to position their surgical instruments. To plan a **procedure** , the surgeon views a **3 - D**) representation of the **patient** 's anatomy, which can be rotated, made transparent or cross-sectioned in any imaginable way...

...fly" through the patient's virtual organs.

The outlook for such surgical training and planning **systems** is promising. Preliminary studies suggest that an hour of training on a surgical simulator is worth three hours with an animal or human cadaver. An added benefit of the virtual **systems** could be to reduce the number of animals needed for the education of a surgeon...
...those savings will require a massive infusion of the technologies into the marketplace. Laparoscopic surgery **systems** in common use today, for instance, generally cost between $40,000 and $60,000. But a 3-D telesurgery **system** still costs at least twice that much.

What is needed are explicit cost-benefit analyses...
19981101

29/5,K/42 (Item 22 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01764598 SUPPLIER NUMBER: 20601096 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Advances in endoscopic **neurosurgery**.
Gerzeny, Michelle; Cohen, Alan R.
AORN Journal, v67, n5, p957(7)
May,
1998
PUBLICATION FORMAT: Magazine/Journal ISSN: 0001-2092 LANGUAGE: English
RECORD TYPE: Fulltext; Abstract TARGET AUDIENCE: Professional; Trade
WORD COUNT: 3773 LINE COUNT: 00320

AUTHOR ABSTRACT: This article describes the authors' experience using neuroendoscopes to perform a variety of intracranial **procedures** with minimal invasiveness to neural tissue. The article also presents the history of neuroendoscopy and provides information about current practice. Surgical technique and intraoperative and postoperative nursing considerations are reviewed. AORN J67 (May 1998) 957-965.

SPECIAL FEATURES: other; illustration
DESCRIPTORS: **Endoscopic** surgery--Technique; Surgical nursing--Practice

Advances in endoscopic **neurosurgery**.

AUTHOR ABSTRACT: This article describes the authors' experience using neuroendoscopes to perform a variety of intracranial **procedures** with minimal invasiveness to neural tissue. The article also presents the history of neuroendoscopy and...

TEXT:

...the basis of a series of technical advances in optics and miniaturization. In recent years, **endoscopic** techniques have been applied successfully to the field of neurosurgery and have begun to revolutionize ...

Endoscopic neurosurgery is appealing for a number of reasons. Small **endoscopes** can be used to gain access to deep intracranial structures through tiny exposures. The surgeon...

...neural tissue. Often, this results in a quicker recovery and shorter hospitalization for the patient. **Endoscopic** techniques are not applicable to all neurosurgical **procedures** , but for certain conditions, neuroendoscopic surgery is superior to conventional approaches and has become the **procedure** of choice. This article reviews the history and evolution of **endoscopic** neurosurgery and describes the current applications of intracranial neuroendoscopy.

HISTORY

Endoscopic neurosurgery began in the early part of this century as an effort to diagnose and...

...urinary bladder could be inserted into fluid-filled cerebral ventricles. In fact, the first neuroendoscopic **procedure** was performed in 1910 by Victor Darwin Lespinasse, who was a urologist, not a neurologist...

...W. Jason Mixter, chief of neurosurgery at the Massachusetts General Hospital, reported the first successful **endoscopic** third ventriculoscopy. This was a new technique he developed to treat hydrocephalus under **endoscopic** guidance by bypassing an obstruction in the ventricular **system** .(4) To fully appreciate Mixter's ingenuity, one must first briefly review the pathophysiology of...

...CSF per day, most of which is generated by the choroid plexus within the ventricular **system** , circulates around the brain and spinal cord, and ultimately is reabsorbed in the venous **system** . Some patients develop an obstruction to the circulation of cerebrospinal fluid, which is known as...

...longer communicates with the subarachnoid space.

Mixter reasoned that if he could enter the ventricular **system** with a small **endoscope** , he might be able to poke a hole in the floor of the third ventricle...

...Medical and Surgical Journal.(6)

Unfortunately, other surgeons did not have the same success with **endoscopic** neurosurgery. The instrumentation was primitive, the optics were poor, and, overall, the morbidity and mortality rates were high. Dandy had developed air ventriculography, which was a superior **method** of imaging the ventricles. By the early 1950s, after the first successful implantation of a...

...ventricular shunting became the preferred surgical technique for treating symptomatic hydrocephalus, and interest in ventricular **endoscopy** faded.(7)

In recent decades, there has been a resurgence of interest in neuroendoscopy. Ventricular...

...for treating hydrocephalus. Advances in both optics and miniaturization made it practical to consider using **endoscopes** once again for neurosurgical purposes. The person most responsible for a renewal of interest in...

...from the University of Reading in Great Britain. Harold Hopkins made numerous advances in optical **system** design and helped usher the field of general **endoscopy** into the modern era. Hopkins' innovations are responsible for the two types of **endoscopes** --rigid and flexible--in general use today. Rigid **endoscopes** contain a solid rod lens developed by Hopkins that provides excellent image resolution. Flexible **endoscopes** make use of the fiber-optic bundle, also developed by Hopkins, and have the advantage...PATIENT SELECTION

At Rainbow Babies and Childrens Hospital, Cleveland, we use both rigid and flexible **endoscope** **systems** to perform a variety of intracranial **procedures** .(9) We have used the **endoscope** to **guide** the placement of ventriculoperitoneal shunts, and, on occasion, to remove recalcitrant shunt catheters embedded in the choroid plexus. We also have used the **endoscope** to fenestrate ventricular cysts, permitting simplification of shunt **systems** for patients with complex loculated hydrocephalus, in whom scar tissue within the ventricles creates multiple ...

...be shunted individually.

For some patients with hydrocephalus due to aqueductal stenosis, we have performed **endoscopic** third ventriculostomy (ie, Mixter's surgery), which enabled us to control-the condition without the...

...shunting and without the long-term complications associated with shunts. We also have found the **endoscope** useful for removing various intraventricular **tumors** and cysts. Finally, we have been using the **endoscope** to simplify standard "open" microsurgical **procedures** , a technique we call " **endoscope** -assisted microsurgery", in which the **endoscope** allows the surgeon to look around blind corners and see structures that otherwise would have been hidden from the straight-on view of the **operating** microscope. The advantage of **endoscopic** surgery is that, when feasible, it can be performed with minimal disruption of neural tissue...

...to be mobilized rapidly, resulting in shorter hospitalization and cost reduction.

SURGICAL CONSIDERATIONS

Before a **procedure** is scheduled, informed consent is obtained from the patient or responsible guardian. Patient teaching is...

...technique that is proposed. Drawings of the brain and three-dimensional models of the ventricular **system** are extremely helpful in showing the nature of the **procedure** . The surgeon also reviews the diagnosis and particular type of intervention with the nursing staff...

...Then, at a second visit, usually just before surgery, the nursing staff members review the **procedure** with the patient and family members, often using pictures and models again. This gives the...

...any further questions the patient or family members may have and also helps reduce the **patient** 's **preoperative** anxiety. Discharge **planning** is discussed, and **patients** are reminded that they probably will spend one day in the intensive care unit and...

...injury to ventricular arteries or veins, as well as injury to neural

structures by the **endoscope** or **endoscopic** instruments. These risks are not unique to **endoscopic procedures** , but may occur with any intracranial surgery. What is unique about **endoscopy** , however, is that the small exposures sometimes may make it difficult to deal with serious...

...there is a small but real risk that if bleeding develops and cannot be controlled **endoscopically** , an open craniotomy might be required. We keep a craniotomy tray in the room during all **endoscopic** : **procedures** , but to date we have not had to convert an **endoscopic** case to an open craniotomy. In **endoscopic** neurosurgical **procedures** , the best way to deal with the problem of bleeding is to avoid it by...

...given a general description of neuroendoscopy and a detailed description of the type of neuroendoscopic **procedure** being performed (eg, third ventriculostomy, colloid cyst removal). **Procedures** vary in **length** from minutes (eg, shunt placement) to hours (eg, **endoscope** -assisted microsurgical **procedures**). Almost all **procedures** are performed through small incisions in the patient's skin, requiring minimal shaving of the hair.

Endoscopic neurosurgical **procedures** are "high-tech" **operations** that require a coordinated effort between the nursing staff and the surgical team. The nurse's role begins with the gathering and assembly of the necessary equipment. For most **procedures** , we use a rigid **endoscope system** (Figure 2) that includes an introducing cannula and obturator with viewing and working lenses. Also on the surgical field are an assortment of microinstruments for use through the **endoscope** 's working channels, including scissors, grasping and **biopsy** forceps, suction catheters, a bipolar coagulator, and sometimes a fiber-optic neodymium:yttrium aluminum garnet (Nd:YAG) laser for dissecting **tumors** or cyst walls. The setup also includes a monitoring console that contains a television screen...

...printer.

(Figure 2 ILLUSTRATION OMITTED)

The scrub person uses two tables--one to hold the **endoscopic** equipment and the other to hold the standard surgical instruments. The **endoscope** monitoring console is placed at the surgeon's right side, and the laser is placed...

...preparation and draping generally are done to expose a small surgical field. Most of the **procedures** are performed through burr hole exposures. For most ventriculoscopic **procedures** , the patient is positioned supine on a standard OR table. The brow is up and...

...is prepared in the surgical field.

The nursing staff members continue to set up the **endoscope system** while the surgeon creates the burr hole. The scrub person sets up the sterile portion of the **endoscopic** equipment, and the circulating nurse works with the monitoring console by hooking up the appropriate...

...The CCD camera is draped in a sterile fashion and connected to the rod lens **system** . The fiber-optic light cable is plugged into the **endoscope** lens and the light source. Irrigation is provided by using warm lactated Ringer's solution introduced through IV tubing into one of the **endoscope** 's working channels. The **endoscopic** bipolar coagulator is connected to a standard bipolar generator box.

The surgeon and scrub person then check the clarity of the **endoscope system** , focusing the lens on fine print, adjusting the intensity of the light source, and performing...

...recorder and the digital printer and for adjusting the intensity of the

light throughout the **procedure** .

The surgical team members now are ready to proceed. The surgeon opens the dura and coagulates and incises the cortical surface of the brain. The surgeon introduces the **endoscope** through the burr hole into the lateral ventricle using standard landmarks, identical to those used for placing a ventricular shunt catheter. Usually, we introduce the **endoscope** through a standard coronal burr hole. This hole is placed in the midpupillary line, just anterior to the coronal suture. The **endoscope** sheath is directed toward the inner canthus of the ipsilateral eye in one plane and...

...culture and sensitivity. When appropriate, CSF also is sent for cytologic examination as well as **tumor** markers. A zero-degree straightforward viewing lens is inserted. The image of the surgical field ...

...the CCD camera onto the television screen, and the entire OR team now views the **procedure** on the screen.

The surgeon searches for **anatomic landmarks** to allow the team members to become oriented to the ventricular **system** .(10) When the **endoscope** enters the lateral ventricle, the major structure for orientation is the foramen of Monro. This...

...members can see only a small portion of it at any given time through the **endoscope** .

The zero-degree viewing lens now can be switched to a smaller 2-mm **diameter** lens that allows the use of working channels in the **endoscope** 's sheath. Irrigation is provided by warm lactated Ringer's solution, with care taken to...
...one of the working channels to prevent a dangerous buildup of intraventricular fluid. If the **procedure** being performed is a third ventriculostomy, the **endoscope** is carefully directed through the foramen of Monro into the third ventricle, and the third...

...is opened with a blunt probe and balloon catheter (Figure 3). The solid rod lens **endoscope** provides an extremely accurate picture of the anatomy of the ventricular **system** (Figure 4). The surgeon takes great care to avoid injury to the basilar artery, which usually can be seen pulsating beneath the translucent third ventricular floor. If the **procedure** being performed is removal of a ventricular **tumor** , such as a colloid cyst, then the cyst capsule is opened with a Nd:YAG...

...the residual cyst capsule is shrunk down using the laser. At the completion of the **procedure** , the ventricular **system** is irrigated copiously before removal of the **endoscope** . A piece of absorbable gelatin sponge is placed over the burr hole site, and the...

...necessary, a tunneled ventriculostomy catheter can be brought out and connected to a closed drainage **system** .

(Figures 3-4 ILLUSTRATION OMITTED)

POSTOPERATIVE COMPLICATIONS

Postoperatively, anesthesia is reversed and patients usually are...

...at least the first postoperative day and are discharged following a brief hospitalization.

As the **procedures** are performed through small exposures, there usually is minimal trauma to neural structures and patients...

...study on colloid cysts of the third ventricle in adults, researchers found that patients undergoing **endoscopic** aspiration had shorter surgical time, spent fewer days in the hospital, and returned to work...

...infection, and injury to structures such as the fornix, hypothalamus, or cranial nerves. As the **procedures** are performed under direct vision, the risk of complications can be reduced by meticulous attention to detail.

CLEANSING AND STERILIZING THE **ENDOSCOPE**

When the **procedure** is completed, the **endoscopic** instruments are ready for decontamination. The instruments are hand washed with a neutral pH detergent...

...the delicate optics.

The neuroendoscope cannot be put through a washer/sterilizer. Components of the **system** that contain only metal may be put through a wash sterilize cycle, but even this is not recommended because of the delicate nature of the **endoscopic** instruments. The **endoscope** is placed in a plastic protective sheath and then in a perforated metal case or **endoscope** tray. When using a perforated metal case, it is essential to remove the foam to ensure proper sterilization. The **endoscope** , along with the other surgical instruments, is placed in a wire tray. Towels may be... may be wrapped for gas sterilization. Ethylene oxide is used for gas sterilization of the **endoscopic** equipment.

CONCLUSION

Technical advances have resulted in the resurgence of neuroendoscopy and have added a new dimension to neurosurgical nursing care. Concepts from other specialties in perioperative nursing (eg, care, **handling** and use of the **endoscope** , patient management) can be used for patients undergoing neurosurgical **procedures** . The benefits of access to deep intracranial structures through small incisions and decreased trauma to neural tissue make the use of an **endoscope** conducive for select neurosurgical **procedures** . Shorter hospitalization, faster recovery, and earlier return to work make the **procedure** favorable for patients who do not have to undergo open craniotomies.

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Michelle Gerzeny, RN, BSN, is the service...

DESCRIPTORS: **Endoscopic** surgery...

19980500

29/5,K/43   (Item 23 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01729551   SUPPLIER NUMBER: 19969373
Endoscopic **ultrasonography, fine-needle aspiration** biopsy guided **by** endoscopic **ultrasonography, and computed** tomography **in the** preoperative **staging of non-small-cell lung cancer: a comparison study.**
Gress, Frank G.; Savides, Thomas J.; Sandler, Alan; Kesler, Kenneth; Conces, Dewey; Cummings, Oscar; Mathur, Praveen; Ikenberry, Steven; Bilderback, Sandy; Hawes, Robert
Annals of Internal Medicine, v127, n8, p604(9)
Oct 15,
1997
PUBLICATION FORMAT: Magazine/Journal; Refereed   ISSN: 0003-4819
LANGUAGE: English RECORD TYPE: Abstract TARGET AUDIENCE: Professional

ABSTRACT: A screening **procedure** called **endoscopic** ultrasonography that involves taking ultrasound images from within a gastrointestinal tube appears to be useful in identifying patients whose lung cancer has spread to the lymph nodes near the backbone. **Endoscopic** ultrasound was performed on 52 patients with lung cancer and suspected lymph node involvement. Of those patients evaluated with this **procedure** alone, 84% were accurately identified as having lymph node involvement. Nearly all of the patients with lymph node involvement were accurately identified when ultrasound-guided tissue sampling was also added to the evaluation.
AUTHOR ABSTRACT: Background: Current **methods** for detecting mediastinal lymph node involvement with non-small-cell lung cancer can be inaccurate and are often invasive and expensive. Objective: To assess the utility of **endoscopic** ultrasonography, fine-needle aspiration **biopsy** **guided** by **endoscopic** ultrasonography, and computed tomography for the detection of metastases to the posterior mediastinal lymph nodes in non-small-cell lung cancer. Design: Prospective preoperative evaluation of the diagnostic **operating characteristics** of these **procedures** . Setting: Referral-based academic medical center. Patients: 130 consecutive patients with non-small-cell lung cancer who were otherwise good surgical candidates. Interventions: All **patients** had initial computed **tomography** of the chest; those with enlarged nodes were referred for **endoscopic** ultrasonography. **Endoscopic** ultrasonography- **guided** fine-needle aspiration **biopsy** was done on suspicious contralateral posterior mediastinal or subcarinal lymph nodes identified by ultrasonography. At surgery, lymph nodes were dissected and categorized by location and underwent histopathologic evaluation. Results: 52 patients were ultimately enrolled in the study: Thirty-one had thoracotomy with mediastinal dissection, and 21 had **tumors** considered unresectable on the basis of **preoperative** evaluation. **Ultrasonography** without aspiration **biopsy** had an overall accuracy of 84% for predicting metastasis to lymph nodes; computed tomography had an accuracy of 49% (P (is less than) 0.025). Twenty-four **patients** had **ultrasonography** -guided aspiration **biopsy** ; 14 of the 24 were ineligible for surgery because cytology showed malignancy. Results of surgical pathology correlated with negative aspiration cytology results in 9 of 10 patients; the one node with false-negative results contained a 2-mm focus of cancer. The accuracy of ultrasonography-guided aspiration **biopsy** in diagnosing metastasis to lymph nodes was 96%; the results of this test prompted a change in management in 95% of the patient who had the **procedure** . Conclusions: **Endoscopic** ultrasonography alone or with fine-needle aspiration **biopsy** adds useful diagnostic information in determining metastasis to posterior mediastinal or subcarinal lymph nodes

in patients with non-small-cell lung cancer. These **procedures** are especially helpful in the preoperative evaluation of patients with suspicious contralateral mediastinal or "bulky" subcarinal nodes.

SPECIAL FEATURES: table; chart; diagram; diagnostic image; illustration
DESCRIPTORS: **Endoscopic** ultrasonography--Evaluation; Lung cancer, Non-small cell--Diagnosis; Lymphatic metastasis--Diagnosis; Lymph nodes--**Biopsy**
FILE SEGMENT: HI File 149

Endoscopic **ultrasonography, fine-needle aspiration** biopsy guided **by** endoscopic **ultrasonography, and computed** tomography **in the** preoperative **staging of non-small-cell lung cancer: a comparison study.**

ABSTRACT: A screening **procedure** called **endoscopic** ultrasonography that involves taking ultrasound images from within a gastrointestinal tube appears to be useful in identifying patients whose lung cancer has spread to the lymph nodes near the backbone. **Endoscopic** ultrasound was performed on 52 patients with lung cancer and suspected lymph node involvement. Of those patients evaluated with this **procedure** alone, 84% were accurately identified as having lymph node involvement. Nearly all of the patients...
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...ultimately enrolled in the study: Thirty-one had thoracotomy with mediastinal dissection, and 21 had **tumors** considered unresectable on the basis of **preoperative** evaluation. **Ultrasonography** without aspiration **biopsy** had an overall accuracy of 84% for predicting metastasis to lymph nodes; computed tomography had an accuracy of 49% (P (is less than) 0.025). Twenty-four **patients** had **ultrasonography** -guided aspiration **biopsy** ; 14 of the 24 were ineligible for surgery because cytology showed malignancy. Results of surgical...

...negative results contained a 2-mm focus of cancer. The accuracy of ultrasonography-guided aspiration **biopsy** in diagnosing metastasis to lymph nodes was 96%; the results of this test prompted a change in management in 95% of the patient who had the **procedure** . Conclusions: **Endoscopic** ultrasonography alone or with fine-needle aspiration **biopsy** adds useful diagnostic information in determining metastasis to posterior mediastinal or subcarinal lymph nodes in patients with non-small-cell lung cancer. These **procedures** are especially helpful in the preoperative evaluation of patients with suspicious contralateral mediastinal or "bulky ...

DESCRIPTORS: **Endoscopic** ultrasonography...

... **Biopsy**

19971015

29/5,K/44 (Item 24 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01721781 SUPPLIER NUMBER: 19854926 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Computer-assisted endoscopic **sinus surgery. (Home Study Program article which includes examination, answer sheet and learner evaluation)**
Petroff, Paula F.
AORN Journal, v66, n3, p415(13)
Sep,
1997
PUBLICATION FORMAT: Magazine/Journal ISSN: 0001-2092 LANGUAGE: English
RECORD TYPE: Fulltext; Abstract TARGET AUDIENCE: Professional; Trade
WORD COUNT: 4408 LINE COUNT: 00373

AUTHOR ABSTRACT: Until the development and use of computer-assisted localization technology in **endoscopic** sinus surgery **procedures** , surgical risks to patients undergoing **endoscopic** sinus surgery **procedures** included blindness, diplopia, or partial vision loss and damage to the cribriform plates and posterior roofs of their ethmoidal sinuses. Successful patient outcomes were dependent on the ability of surgeons to visualize surgical sites directly, to correlate data from two-dimensional computed tomography scans, and to apply these data to **anatomic landmarks** . Advances in computer-imaging modalities and computer-assisted localization technology have eliminated many of the surgical problems and patient complications associated with early **endoscopic** sinus surgery **procedures** and have caused fundamental changes in the way otorhinolaryngologists diagnose and treat patients with sinus disease.

SPECIAL FEATURES: photograph; illustration
DESCRIPTORS: **Endoscopic** surgery--Computer programs; Paranasal sinuses--Surgery

Computer-assisted endoscopic **sinus surgery. (Home Study Program article which includes examination, answer sheet and learner evaluation)**

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...to correlate data from two-dimensional computed tomography scans, and to apply these data to **anatomic landmarks** . Advances in computer-imaging modalities and computer-assisted localization technology have eliminated many of the surgical problems and patient complications associated with early **endoscopic** sinus surgery **procedures** and have caused fundamental changes in the way otorhinolaryngologists diagnose and treat patients with sinus...

TEXT:

Surgical techniques for **endoscopic** sinus surgery **procedures** were developed in Germany and Austria in the late 1970s; however, otorhinolaryngologists in the United States did not perform **endoscopic** sinus surgery **procedures** until 1985.(1) Since 1990, the combined use of sinuscopes, advanced computer-imaging modalities, and...

... use computed tomography (CT) scans in conjunction with head-mounted

stereotactic frames to target brain **lesions** .(3) During the 1980s, advancements in computer-assisted localization technology resulted in the development of frameless stereotactic targeting **systems** that were less cumbersome and more maneuverable than head-mounted stereotactic frames. Otorhinolaryngologists first used computer-assisted localization technology in **endoscopic** sinus surgery **procedures** in 1987.(4)

Before the introduction of computer-assisted **endoscopic** sinus surgery (CAESS) **procedures** , patients who underwent **endoscopic** sinus surgery were faced with certain surgical risks, which included blindness, diplopia, or partial vision...

...the cribriform plates and posterior roofs of their ethmoidal sinuses.(5) Successful patient outcomes from **endoscopic** sinus surgery **procedures** not involving CAESS technology were dependent on the ability of surgeons to directly visualize surgical sites, correlate data from two-dimensional CT scans, and apply these data to **anatomic landmarks** .

ADVANCE TECHNOLOGY FOR COMPUTER-ASSISTED **ENDOSCOPIC** SINUS SURGERY **PROCEDURES**

The goal of CAESS technology is to ensure that **endoscopic** sinus ensure **procedures** are safer for patients and less invasive. This technology combines the use of computerized planning tools and intraoperative **navigation systems** into **endoscopic** sinus surgery **procedures** for the treatment of sinus disease. When CAESS technology is applied to **endoscopic** sinus surgery **procedures** , surgical risks to patients decrease dramatically. Otorhinolaryngologists often use CAESS technology to surgically treat paranasal...

...decompress patients' orbital contents in Graves' disease; and drain orbital and epidural abscesses.(6)

INTRAOPERATIVE **NAVIGATION SYSTEM**

We performed our first CAESS **procedure** at Saint Vincent Surgery Center, Erie, Pa, in 1992. Surgical staff members at our facility agreed to participate in a research project that involved the use of an experimental intraoperative **navigation system** for CAESS **procedures** . The research project's goal was to obtain the US Food and Drug Administration's (FDA's) approval of this intraoperative **navigation system** for use in future CAESS **procedures** .

An intraoperative **navigation system** usually consists of an imaging workstation with a high-resolution computer monitor, a coordinate digitizer, and interfaces to the coordinate digitizer (eg, fiducial markers, sterile **navigation** probe, articulated arm). The computer monitor displays four images simultaneously: the triplanar **image** of the **patient** , which includes axial, sagittal, and coronal views of two-dimensional CT scans; and a **three** -dimensional reconstructed or **virtual image** of the **patient** .

The articulated arm is a six-jointed passive mechanical arm. Before the CAESS **procedure** begins, the circulating nurse connects the articulated arm to the side of the OR bed...

...each of the six joints of the articulated arm provide positional information regarding the relative **angles** of the arm's segments. The scrub person attaches a sterile **navigation** probe to the last joint of the articulated arm, unlocks the arm, and fully extends it over the sterile field during the CAESS **procedure** .

Sterile **navigation** probes come in two different sizes (Figure 2). The surgeon identifies and measures which **navigation** probe he or she wishes to use before the CAESS **procedure** begins. A sales representative from the manufacturer of the intraoperative **navigation system** enters the size of the **navigation** probe into a portable computer as part of the

initial setup for the CAESS **procedure** . The computer uses this information along with known geometric data to compute the exact position in space of the tip of the **navigation** probe during the CAESS **procedure** .

PREOPERATIVE PATIENT CARE

The surgeon explains the CAESS **procedure** and possible complications to the patient during the patient's preoperative office visit. The office nurse schedules the patient's CAESS **procedure** , **preoperative** **CT** scans, and other **preoperative** diagnostic testing (eg, laboratory tests, chest x-ray, 12-lead electrocardiogram (ECG)) with the ambulatory...

...the patient's age, sex, and the types of anesthetic medications administered during the CAESS **procedure** . Our facility requires female patients older than 12 years of age to have preoperative hematocrit and hemoglobin levels drawn.

Placement of fiducial markers, **preoperative** computed **tomography** scans. The office nurse tells the patient that eight to 12 fiducial markers (ie, radiographic registration markers) will be placed on his or her forehead and cheeks immediately before the **preoperative** **CT** scans are taken for fiducial registration during the CAESS **procedure** . Fiducial markers are small (ie, approximately one-half inch in **diameter**), circular, and self-adhering. These radiopaque markers are used to create identical patterns of **anatomic** **landmarks** between the **patient** 's **preoperative** **CT** scans and his or her face during the CAESS **procedure** . The office nurse cautions tile patient not to remove or disturb the fiducial markers or get them wet after they have been placed because the accuracy of the fiducial registration **process** during the CAESS **procedure** is dependent on the markers' initial placement. The accuracy of the fiducial registration **process** is increased if the markers are placed over bony prominences of the patient's face. These fiducial markers remain on the patient's face until the conclusion of the surgical **procedure** the following day.

The patient undergoes his or her **preoperative** **CT** scans the day before surgery. The targeted area of the CT scans includes the top...

...upper incisors. A radiology technician uses a nine-track magnetic tape cassette to transfer the **patient** 's **CT** scan data to a workstation in the radiology department. The surgeon uses data from the cassette to reconstruct a dimensional **model** of the **patient** 's face and underlying bony structures before the CAESS **procedure** . He or she takes the nine-track magnetic tape cassette that contains the three-dimensional reconstructed **image** of the **patient** 's face and the axial, sagittal, and coronal views of the **patient** 's **two - dimensional** triplanar image to the OR the day of surgery. These four images appear on the intraoperative **navigation** **system** 's workstation computer monitor during the CAESS **procedure** (Figure 3).

Telephone **instructions** . A surgery center staff nurse telephones the patient the day before the scheduled CAESS **procedure** . He or she reviews the patient's NPO **instructions** and verifies that arrangements have been made for a responsible care provider to escort the...
...the circulating nurse interviews the patient, he or she loads the cassette that contains the **patient** 's **CT** scan data into the intraoperative **navigation** workstation's computer located in the OR. He or she ensures that the three-dimensional reconstructed **model** of the **patient** 's face and the axial, sagittal, and coronal views of the **patient** 's **two - dimensional** triplanar image are displayed on the workstation's computer monitor before the patient's arrival...

...the OR.

We initially found it necessary to have two circulating nurses

present during CAESS **procedures** : one nurse to **operate** the computer and one nurse to perform routine circulating duties. As we gained experience and speed with the intraoperative **navigation system** , fiducial registration times were reduced to less than 10 minutes. As this time frame did...

...nurse needed to assist the anesthesia care provider or the scrub person, the fiducial registration **process** could be stopped and resumed without interfering with the computer's accuracy.

The circulating nurse...

...reports any moved, removed, or reapplied fiducial markers to the surgeon before the fiducial registration **process** begins to prevent inaccurate computer readings.

INTRAOPERATIVE PATIENT CARE

The circulating nurse accompanies the patient...

...s soft tissues under the markers to avoid inaccurate fiducial registration readings during the CAESS **procedure** .

The surgeon places cottonoids saturated with oxymetazoline hydrochloride in the patient's nostrils before scrubbing...

...the surgeon and the scrub person drape the patient. The surgeon performs both fiducial and **anatomic landmark** registrations before he or she begins the surgical **procedure** .

Fiducial registration. Fiducial registration is used to correlate the contour of the patient's face...

...and the three-dimensional reconstructed image displayed on the computer monitor. Before the fiducial registration **process** begins, it is imperative to know which, if any, of the fiducial ...also is necessary for the circulating nurse to carefully watch the surgeon place the sterile **navigation** probe on each fiducial marker during the registration **process** . Too much pressure on the probe may cause tissue distortion beneath the marker and subsequently affect the accuracy of the registration.

Registration sequence. To begin the fiducial registration **process** , the surgeon touches the tip of the sterile **navigation** probe to a fiducial marker on the patient's face (Figure 6). The circulating nurse...

...which appears as a crosshair, on the computer monitor to the corresponding point on the **three** -dimensional **image** of the **patient** (Figure 7). These two points are entered into the computer as a correlation. The computer...

...scan and the exact place in space of the probe tip to be relevant. This **process** is repeated until all but two of the fiducial markers have been correlated. The two...

...total RMS value of the set of points and increases the accuracy of the intraoperative **navigation system** . Registration inaccuracy also occurs when fiducial markers are moved or too much pressure is placed...

...which causes indentations in the patient's facial soft tissues, at the time of correlation.

Anatomic landmark registration. **Anatomic landmark** registration uses the patient's physical features and facial contours as landmarks. The surgeon places the tip of the sterile **navigation** probe on the lateral canthal area of the patient's right eye. The circulating nurse ...

...on the computer monitor to the right lateral canthal area on the three-dimensional reconstructed **image** of the **patient** and enters this correlation into the computer. As in the fiducial registration, the computer recognizes...

...uses the mouse to place the computer into a "skin" mode. This allows the intraoperative **navigation system** to receive and correlate the contour of the patient's face. While the cursor is set on "surface," the surgeon touches the sterile **navigation** probe to approximately 40 fudicial markers on the patient's face. Each of these points...

...face to an identical contour pattern that has been created on the three-dimensional reconstructed **image** of the **patient** . As the registration is entered into the computer, a corresponding RMS value appears. Any movement...

...s head creates an inaccurate registration, which requires recalibration of the registration sequence. An abbreviated **process** can be performed by using four **anatomic landmarks** established after the registration **process** . If movement occurs, the computer **operator** selects the list of established landmarks. The landmarks are highlighted individually as the surgeon places the sterile **navigation** probe on the predetermined landmarks and the computer is instructed to reestablish the landmarks. This **method** corrects any deviations that may be created by movement of the patient's head.

Computer accuracy checks. When the registration **process** is completed, the computer shows the position of the probe's tip in real time to allow the surgeon to accurately identify his location at any time during the surgical **procedure** . Accuracy is determined by the RMS value and a visual accuracy check. The surgeon visually...

...appears. After both fiducial and anatomic registrations have been completed, the surgeon chooses the registration **process** he or she believes is more accurate.

Surgical **procedure** . After the surgeon takes the fiducial and anatomic registrations, he or she begins the surgical **procedure** . The sterile **navigation** probe's used to identify the surgeon's position and **anatomic landmark** throughout the surgical **procedure** . The surgeon initially uses the **navigation** probe to identify the bulla ethmoidalis and to confirm his or her position medial to...
...to identify diseased cells in the patient's sphenoidal sinuses. The surgeon also uses the **navigation** probe to identify the exact point of penetration into the patient's maxillary sinuses and...the PACU nurses a complete report on the patient's intraoperative status during the CAESS **procedure** . The PACU nurses apply an oxygen mist mask to the patient's face and record...

...without experiencing nausea or vomiting, the PACU nurses remove the patient's IV line.

Discharge **instructions** include reminding the patient of the importance of eliminating any unnecessary sinus pressure. The PACU nurses instruct the patient not to blow his or her nose, **bend** forward, lift heavy objects, or strain during bowel movements. They tell the patient to expect some sinus drainage from his or her nose. The nurses give the patient specific **instructions** on what to do if bleeding occurs and when to call the surgeon and the surgery center nurses. After the PACU nurses give complete and detailed discharge **instructions** to the patient and his or her adult care provider, they give them telephone numbers...

...call on the first postoperative day to check his or her progress.

DISCUSSION

The intraoperative **navigation system** used in our research project is a significant improvement to the traditional fluoroscopic- **guided method** previously used in CAESS **procedures** . Compared to the fluoroscopic- **guided method** , the intraoperative **navigation system** offers a more complete view of the **patient** 's anatomic **planes** , is more maneuverable, and decreases the risks of radiation exposure from fluoroscopy to the patient...

...need to wear cumbersome radiation protective aprons during surgery. One minor disadvantage to the intraoperative **navigation system** is the need to perform a second axial CT scan during the CAESS **procedure** . The radiation exposure associated with this additional CT scan, however, is far less than the radiation exposure from fluoroscopy.(8)

Revision surgical **procedures** , facial trauma injuries, paranasal, nasopharyngeal, and sphenoidal sinus disease are specific indications for the use of intraoperative **navigation systems** during CAESS **procedures** .9with continued research, CAESS technology may play an important role in other head and neck surgical **procedures** (eg, drainage of orbital, epidural abscesses secondary to complications of acute sinusitis; decompression of orbital...

...not a substitute for a thorough understanding of anatomy and physiology, a working knowledge of **endoscopic** sinus surgery techniques, and experienced otorhinolaryngologists and OR nurses, it can prove invaluable for improving surgical accuracy during **endoscopic** sinus surgery **procedures** .

One of the most unexpected problems for learning the intraoperative **navigation system** was the inability of some of our circulating nurses to use the computer mouse. The...

...computer to coordinate the surgeons' actions, as well as their own, during the fiducial registration **process** . After our surgeons performed the first few CAESS **procedures** at our facility, they recognized that too much pressure was being applied to the soft...

...project continued, however, the surgeons were able to develop a better feel for the sterile **navigation** probe, which resulted in a steady, lighter touch during use of the probe and more accurate fiducial registrations.

CONCLUSION

As more surgical **procedures** are performed in ambulatory surgery centers, perioperative nurses will be challenged to become more involved...

...there is no guarantee that this support will be available to circulating nurses during CAESS **procedures** . Our research project involving a new intraoperative **navigation system** for CAESS **procedures** was successful due to the teamwork, cooperation, and innovative ideas of our surgical staff members...

...accomplished and that the FDA had granted its approval for the use of our intraoperative **navigation system** in CAESS **procedures** .

NOTES

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DESCRIPTORS: **Endoscopic** surgery...
19970900

29/5,K/48 (Item 28 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01635526 SUPPLIER NUMBER: 18616085 (USE FORMAT 7 OR 9 FOR FULL TEXT)
Endoscopic **ultrasonography and real-time** guided **fine-needle aspiration** biopsy **of solid** lesions **of the mediastinum suspected of malignancy.**
Pedersen, Birthe H.; Vilmann, Peter; Folke, Kirsten; Jacobsen, Grete Krag; Krasnik, Mark; Milman, Nils; Hancke, Soren
Chest, v110, n2, p539(6)
August,
1996
PUBLICATION FORMAT: Magazine/Journal ISSN: 0012-3692 LANGUAGE: English
RECORD TYPE: Fulltext TARGET AUDIENCE: Professional
WORD COUNT: 2720 LINE COUNT: 00277

SPECIAL FEATURES: illustration; photograph; table; diagnostic image
DESCRIPTORS: **Endoscopic** ultrasonography--Diagnostic use; **Biopsy** , Needle --Analysis; Mediastinum-- **Biopsy** , Needle
FILE SEGMENT: HI File 149

Endoscopic **ultrasonography and real-time** guided **fine-needle aspiration** biopsy **of solid** lesions **of the mediastinum suspected of malignancy.**

TEXT:
Study objective: The study details our preliminary experience with **endoscopic** ultrasonography (EUS) **guided** fine-needle aspiration **biopsy** (FNAB) of mediastinal masses suspected of malignancy.
Design: Prospective uncontrolled study.
Patients: Nine patients had **lesions** suspected of malignancy ranging from 1 to 9 cm in **diameter** in various locations of the mediastinum.
Interventions: The EUS examination was performed with a gastroscope (Hitachi/Pentax FG-32 UA) equipped with an adjustable 5- or 7.5-MHz **curved** array ultrasonic transducer. The scanning plane is in the long axis of the **endoscope** allowing endosonographically **guided** **biopsy** to be performed.

A 21-gauge (0.8 mm), full- **length** steel needle housed in a **biopsy** handle (type: Hancke/Vilmann; GIP-Medizin Technik; Grassau, Germany) was used for the **biopsies** .

Results: Nine patients had **biopsy** specimens taken from 13 **lesions** . The total number of needle passes was 18 (range, 1 to 3; median, 1.4). The cytologic diagnosis was conclusive for cancer in ten **lesions** and consistent with a bening **lesion** in three **lesions** . All ten malignant diagnoses and two benign diagnoses were confirmed either by operation or follow-up. In the last patient with lung cancer, a final diagnosis of the EUS-guided **biopsy** of an enlarged lymph node could not be obtained. No false-positive or negative **biopsy** diagnoses were recorded. The **biopsy procedure** was well tolerated by all patients, and there were no complications.

Conclusions: EUS-guided aspiration **biopsy** is a significant advance in the differentiation between malignant and bening **lesions** of the mediastinum carrying a high diagnostic potential.

Key words: **biopsy** , needle; diagnostic imaging; endosonography; gastrointestinal **endoscopy** ; lung cancer; mediastinum; staging

Abbreviations: EUS= **endoscopic** ultrasonography; FNAB=fine-needle aspiration **biopsy**

Endoscopic ultrasonography (EUS) has established its value as the preferred **method** for TN staging and evaluation of resectability in cancers of the upper GI tract.(1),(2),(3),(4) By endosonography, most **lesions** in and adjacent to the GI tract can be imaged. This also applies to solid **lesions** of the mediastinum. Recently, it has become possible to obtain cytologic samples from mediastinal masses guided by EUS.(5),(6),(7) Several other techniques are available for obtaining **biopsy** specimens from mediastinal masses, eg, mediastinoscopy, CT-guided **biopsy** , and transbronchial fine-needle aspiration. However, each technique has its limitations, either because of small-sized **lesions** or because some areas in the mediastinum are inaccessible to **biopsy** . In the following, we present our preliminary experience with EUS-guided fine-needle aspiration **biopsy** (FNAB) of mediastinal masses, including lymph nodes, since this **method** appears to be of significant value for the tissue diagnosis of such **lesions** .

MATERIALS AND **METHODS**

Nine patients, five men and four women, had a median age of 62 years (range...

...suffering from lung cancer (cases 1, 2, 4, 6, 8, and 9). In these six **patients** , **CT** scanning of the chest showed a solid **lesion** of the lung in close continuity with the mediastinum. Additionally, in five of the six **patients** , **CT** scanning showed lymph nodes in the mediastinum. Findings from fiberoptic **bronchoscopy** (five patients) and/or mediastinoscopy (four patients) were inconclusive in these patients. In none of...

...with persistent hiccup who was referred with enlarged lymph nodes in the mediastinum outlined by **CT** . Another **patient** (case 7) with a pancreatic cancer and a persistent infiltrate in the upper left lobe...

...staging examination. The last patient (case 5) was referred for EUS because of a solid **lesion** in the lower mediastinum suspected to be located adjacent to the esophagus by **CT** . This **patient** was treated 6 years prior to the referral for a malignant carcinoid **tumor** in the mediastinum.

The EUS examination was performed with a fiberoptic oblique forward-viewing gastroscope (Hitachi/Pentax FG-32 UA) incorporating a 100 (degrees) **curved** array ultrasonic transducer that allows scanning at 5 and 7.5 MHz (Fig 1). The scanning plane is oriented parallel to the long

axis of the scope. A 2-mm- **diameter** **biopsy** channel permits passage of a needle into the sector-shaped ultrasound field. The **endoscope** is connected to an ultrasound scanner (Hitachi EUB-515) also allowing duplex and color Doppler scanning.

The needle used for the aspiration **biopsy** is a 21-gauge (0.8 mm) solid steel needle housed in a **biopsy** handle that can be screw fixated to the inlet of the **biopsy** channel of the **endoscope** (Fig 2). The needle can be advanced up to 10 cm beyond the distal end of the **biopsy** channel by manipulation of a piston in the handle end of the **biopsy** instrument. This means that not only **lesions** within the GI wall but also distant **lesions** outside the GI wall can be punctured. The entire **biopsy** instrument was developed at our ultrasonic laboratory in collaboration with a manufacturer (GIP-Medizin Technik...

...in a left lateral decubitus position, and midazolam was administered for conscious sedation. The ultrasound **endoscope** was advanced into the stomach. The instrument was gradually withdrawn with continuous **rotation** of the probe allowing inspection of the periesophageal space. When the target was visualized by...
...needle was introduced through the esophageal wall guided by ultrasound into the middle of the **lesion** and material was sampled by means of to-and-fro movements of the needle tip...

...a cytopathologist.

Chest CT scanning was performed with a scanner (GE model 9800; GE Medical **Systems** ; Milwaukee).. Contiguous 10-mm-thick sections were acquired from the lung apices to the diaphragm...

...Lymph nodes were measured and considered abnormal if they exceeded 10 mm in short axis **diameter** .(8)

The ...Table 2 summarizes the results of the diagnoses obtained by EUS FNAB. Nine patients had **biopsy** specimens taken from 13 **lesions** . The total number of needle passes was 18 (range, 1 to 3; median, 1.4). The cytologic diagnosis was conclusive for cancer in 10 **lesions** (cases 1, 2, 4, and 6 through 9) and in 3 **lesions** the specimen aspirated was consistent with a benign **lesion** (cases 1, 3, and 5). There were no significant differences in the number of needle passes for diagnosing a benign **lesion** vs a malignant **lesion** .

(Part 1 of 3)

Table 1--Data From Patients Referred for EUS-Guided FNAB

Case...

...7-cm mass in the	mediastinum, presumably caused by a **tumor** in the left side of mediastinum	upper left mediastinum, including left lung hilum 2: Enlarged lymph nodes beneath the aortic...
...3	Normal	Enlarged lymph nodes in the right lower paratracheal region and posterior to the **carina**

4	6-cm left hilar mass 7x6x4 cm in **diameter**	1: 5-cm left hilar mass 2: Enlarged lymph nodes in the lower left paratracheal region
5	Normal	2-cm solid mass **lesion** posterior to the esophagus
6	Mass **lesion** of the upper right lobe	4-6-cm mass in the superior mediastinum
7	Infiltration...	

...mediastinal mass

8	7x5x4-cm left hilar mass	1: Left hilar mass 6x6x8 cm in **diameter** 2: Enlarged lymph nodes in lower left paratracheal region
9	Mass **lesion** in the upper right lobe	4x5x7-cm right paravertebral mass **lesion**

(Part 2 of 3)

Table 1--Data From Patients Referred for EUS-Guided FNAB

Case No.	EUS	EUS-FNAB Diagnosis
1	1: Solid mass **lesion** in the left upper paratracheal region surrounding the aortic	1: Poorly differentiated carcinoma 2: Normal...

...paratracheal region at

	arch and left subclavian artery 2: 10-mm lymph node near the **lesion** .	
3	Several lymph nodes in the mediastinum (**diameter** , 20 mm)	Normal lymphatic cells
4	1: 2.8-cm mass under the aortic...	1+2: Small cell

...left

	differentiated side 2: Several 10-mm lymph nodes in this area	adenocarcinoma
5	Submucosal **tumor** in the esophageal wall 2.5	Benign smooth muscle cells

cm in **diameter**

6	1: 7-cm solid mass in the right superior	1: Adenocarcinoma 2: Not punctured...

...1: 6-cm solid mass in the left aorticopulmonary window | 1: Carcinoma
2: 1.5-2.0-cm enlarged lymph nodes in the subcarinal region | 2: Necrosis and **tumor** cells
3: 1.5-cm lymph nodes in the lower left paratracheal region... | 3: Not punctured
4: **Tumor** cells

...by clinical follow-up, thoracotomy, or autopsy. EUS FNAB demonstrated cancer cells in all these **lesions** . Figures 3 and 4 show a typical solid **lesion** (case 1).

Table 2--Accumulated Results of EUS-Guided FNAB of Mediastinal **Lesions**

Final Diagnosis	Cytology Malignant	Benign	
Malignant	10	0	10
Benign	0	2	2
Unknown	0...		

...with a left hilar mass (case 2) and enlarged lymph nodes adjacent to the primary **lesion** , **biopsy** specimens of the lymph nodes were not taken.

In one patient with lung cancer in...

...not operated on (case 1).

In the patient with pancreatic cancer (case 7), a metastatic **lesion** in the mediastinum was confirmed by autopsy. In another patient with benign lymph nodes diagnosed...

...years (case 3). In the patients having the diagnosis verified, no false-positive or negative **biopsy** diagnoses were recorded. The **biopsy** **procedure** was well tolerated by all patients, and there were no complications.

DISCUSSION

Our preliminary results of EUS-guided **biopsy** in patients with solid mass **lesions** of the mediastinum suspected of malignancy demonstrate that the technique seems to provide an excellent possibility for differentiation between benign and malignant **lesions** . In our experience, even small **lesions** of less than 1.0 cm can be targeted precisely.(6), (7) In eight **patients** in whom **CT** scanning had imaged enlarged lymph nodes and/or a solid mass **lesion** in the mediastinum, EUS with FNAB successfully revealed the cytologic diagnosis. Although this study is an uncontrolled study, it should be noted that mediastinoscopy and/or **bronchoscopy** had failed to obtain a diagnosis in six of the patients, indicating that the present...a wide range for sensitivity and specificity reported in the literature.(10), (11), (12) Other **methods** include transbronchial FNAB and CT- **guided** FNAB, but these **methods** are not always successful.

EUS permits imaging of the paraesophageal space and seems to provide ...

...visualization of lymph nodes in the mediastinum.(13), (14), (15) In

these studies, an ultrasound **endoscope** with a 360(degrees) mechanically rotating transducer was used. This **method** gives an excellent overview of the structures in the mediastinum, but contrary to a linear...

...complication rate is in accordance with our own and other authors' experience with EUS-guided **biopsy** of solid **lesions** of the pancreas and periintestinal lymph nodes, including mediastinal lymph nodes.(3), (6), (7), (16...

...patients.

We consider EUS-guided FNAB to be advantageous compared with mediastinoscopy and CT-guided **biopsy** of mediastinal **lesions** for several reasons. First, the continuous visualization of the needle is recognized when performing the aspiration and thereby avoiding puncture of vascular structures. Second, the EUS FNAB **procedure** for mediastinal **lesions** is usually less time consuming, averaging about 5 to 10 min. And third, puncture through the esophagus is painless and seems to be less traumatic for the patients than other **methods** . Finally, general anesthesia is not necessary in contrast to mediastinoscopy.

In the future, we believe that EUS with FNAB will become a supplementary **method** of providing cytologic diagnoses of a suspected primary **tumor** within the mediastinum and for diagnosis of mediastinal lymphadenopathy in patients with lung cancer, hopefully...

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DESCRIPTORS: **Endoscopic** ultrasonography...

... **Biopsy** , Needle...

... **Biopsy** , Needle
19960800

29/5,K/50 (Item 30 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01603677 SUPPLIER NUMBER: 17480061 (USE FORMAT 7 OR 9 FOR FULL TEXT)
The diagnostic and therapeutic utility of thoracoscopy: a review.
Harris, Randall J.; Kavuru, Mani S.; Rice, Thomas W.; Kirby, Thomas J.
Chest, v108, n3, p828(14)
Sept,
1995
PUBLICATION FORMAT: Magazine/Journal ISSN: 0012-3692 LANGUAGE: English
RECORD TYPE: Fulltext TARGET AUDIENCE: Professional
WORD COUNT: 10002 LINE COUNT: 00866

SPECIAL FEATURES: illustration; photograph; table; diagram
DESCRIPTORS: Thoracoscopy--Evaluation
FILE SEGMENT: HI File 149

TEXT:
EUO=effusion of unknown origin; SPN=solitary pulmonary nodule; TTNB=transthoracic needle **biopsy** ; VATS= video-assisted thoracoscopic surgery
Key words: malignancy; needle **biopsy** ; pleural disease; thoracoscopy; **tumor**
Intrathoracic disease involving the lung and pleura remains a frequently encountered and challenging clinical problem. The cause of lung or pleural abnormalities may remain unknown despite thoracentesis, closed pleural **biopsy** , transthoracic needle aspiration, or **bronchoscopy** . Recent advances in **endoscopic** technique, video equipment, and the development of better instrumentation have contributed to the resurgence of ...

...thoracoscopic surgery (VATS), is now used for solitary pulmonary nodule resection, metastatic resections, open lung **biopsies** , pericardiectomies, pneumothorax repair, and pleural space drainage **procedures** . It has become an alternative approach for sympathectomy for upper extremity hyperhidrosis, sympathetic dystrophy, and...

...the indications for VATS continue to evolve.[3-6]
Although thoracoscopy is used for such **procedures** , adequate controlled trials confirming its superiority to conventional open thoracotomy are lacking. Its evaluation has...

...This review provides critical commentary regarding thoracoscopy's technique, advantages, disadvantages, diagnostic utility, therapeutic and **operative** applications, complications, and controversies.
PROCEDURE DESCRIPTION
Simple Rigid Thoracoscopy (Without Video Assistance)
Simple rigid thoracoscopy (without video assistance) must be...

...of the pleural space. Simple rigid thoracoscopy can be performed under local anesthesia in an **endoscopy** suite or under general anesthesia in an

operating room. When performed under general anesthesia, a...

...one-lung ventilation. The anesthesiologist selectively ventilates the lung opposite to the side of the **procedure** . This technique provides excellent exposure of the affected pleural cavity.

For simple rigid thoracoscopy, the...

...is inspected. Several entry points for different viewing axes are sometimes needed. Scopes of various **diameters** are available. Video assistance and magnification are typically not necessary for simple diagnostic thoracoscopy. Telescopes with varying oblique **angles** are available to ensure adequate vision.

If a pleural effusion exists, it is drained and sent for cytologic and microbiologic analysis where applicable. **Biopsy** forceps are used to obtain tissue samples adequate for diagnosis. Specimens are preferentially taken over...

...surgeons, VATS is a surgical technique used to potentially minimize the morbidity of an open **procedure** . Some institutions use video equipment for both the diagnostic and **operative** **procedures** . We believe video assistance is indicated primarily for the more complex therapeutic and **operative** **procedures** . These **procedures** often require improved visualization and precise instruments. The development of an **endoscopic** stapler that simultaneously cuts, staples, and limits air leaks was a major advancement for the VATS technique.

Certain VATS **procedures** can be performed under local anesthesia, but VATS typically requires general anesthesia and is performed...

...Simple rigid thoracoscopy offers the physician several distinct advantages over thoracentesis and percutaneous closed pleural **biopsy** , namely (1) direct visualization of the thoracic cavity (2) lysis of pleural adhesions allowing full inspection, (3) guided tissue **biopsies** , (4) control of bleeding, and (5) the application of minor therapeutic maneuvers (Table 1). The...

...and Disadvantages Advantages(*)

Direct visualization of chest cavity
Lysis of adhesions allowing inspection
Guided tissue **biopsies**
Easier control of bleeding
Therapeutic and operative applications
Reduced recovery time and cosmesis[dagger] Disadvantages
Invasive **procedure**
Cost
Loss of parenchymal palpation[double dagger]
Loss of binocular vision[dagger] (*) Compared with thoracentesis or closed pleural **biopsy** . [dagger] Select surgeries.[5,7,37] [double dagger] Compared with open ...have several disadvantages. Each is costly and invasive compared with thoracentesis and percutaneous closed pleural **biopsy** . Each usually requires hours to days of chest tube drainage postprocedure. VATS has several disadvantages...

...2) loss of binocular vision, and (3) difficulty with hemorrhage control. Moreover, 20% of VATS **procedures** require conversion to thoracotomy, which can add operative time and cost.[7] Serious complications have...

...a consequence of local disease of the lung or pleura or as a manifestation of **systemic** disease. The relative ease of access to the pleural space allows pleural fluid and tissue to be evaluated diagnostically. Conventional sampling consists of thoracentesis and percutaneous closed pleural **biopsy** . Thoracoscopy is often performed

because these **procedures** are nondiagnostic.

Cytologic analysis of thoracentesis fluid is positive in 45 to 80% of malignant...

...additional yield for malignancy).[14,18] Thus, some advocate the addition of a closed pleural **biopsy** to further increase diagnostic yield.[18]

Closed pleural **biopsy** is reported to be diagnostic for pleural malignancy in approximately 50% of cases.[16,17...

...disease in 281 (68%) patients. Fluid cytologic study was positive in 163 (58%), closed pleural **biopsy** positive in 121 43%), either positive in 183 (65%). However, in only 20 (7%) of the 281 patients with malignant effusion, closed **biopsy** specimens revealed malignant disease when the fluid cytologic study was negative. This study is often cited as an indication not to do initial concurrent thoracentesis and closed pleural **biopsy** when malignancy is the primary consideration. If the initial thoracentesis fluid is an exudate, with...

...malignancy, it seems reasonable to then repeat thoracentesis with the addition of a closed pleural **biopsy** . In contrast, it is recommended that thoracentesis and closed pleural **biopsy** both be performed initially if tuberculosis is the primary consideration because the combined sensitivity for tuberculosis by thoracentesis culture and closed pleural **biopsy** is greater than 80%.[17,19] Normal findings from thoracentesis and closed pleural **biopsy** , however, give no assurance that malignancy is absent.

Boutin et al[14] note three limitations of thoracentesis and closed needle **biopsy** in evaluating malignant effusions: (1) false-positive cytologic results range from 0.5 to 1...

...and (3) the sensitivities depend directly on the stage of the cancer. Moreover, closed needle **biopsy** is effective in adequately sampling the parietal pleura in only 75% of attempts.[19] Rodriguez...

...is less frequently involved with metastatic pleural disease than the visceral pleura. Localized and diaphragmatic **tumors** are often not even accessible by closed needle **biopsy** . The above limitations account for some of the reduced diagnostic efficacy of thoracentesis and closed needle **biopsy** for malignancy.

Despite extensive conventional evaluation, 10 to 27% of patients with pleural effusions remain...

...23-26] (Table 2). Thoracoscopy increases diagnostic yield for effusions after thoracentesis and closed pleural **biopsy** specimens are nondiagnostic. Thoracoscopy also yields few false-negative results. Boutin et al[14], retrospectively...

...identified 131 of 150 (87%) malignant cases whereas repeated pleural cytologic study and closed needle **biopsy** specimens the day before surgery yielded positive results in only 62 of 150 (41%) malignant...

...had at least two previous negative cytologic specimens and one or more negative closed needle **biopsy** specimens.[15] Hariis et al[15] reported thoracoscopy had a diagnostic sensitivity of 95% for...

...specimens and in 27 of 41 (66%) patients who had a preoperative nondiagnostic closed pleural **biopsy** specimen. In a comparative study of simple rigid thoracoscopy, cytology, and closed needle **biopsy** , Loddenkemper et al[16] reported the diagnostic sensitivities were 95%, 62%, and 44%, respectively. Menzies...

...their prospective study of thoracoscopy in 102 patients with EUO, after thoracentesis and closed needle **biopsy** specimens were nondiagnostic, reported a definitive-diagnosis by thoracoscopy in 95 (94%) patients. Sixty-six...population with EUO. Second, in several series reporting diagnostic accuracy of 90 to 100%, the **length** of follow-up was either not stated or lasted less than 6 months.[9,23...

...address if earlier diagnosis and treatment of malignant pleural disease identified by thoracoscopy improves measurable **parameters** (eg, survival, quality of life, days in hospital). Whether clinical certainty and earlier diagnosis of malignancy benefit the patient enough to warrant the costs and potential morbidity of this invasive **procedure** remains to be determined.

Currently, thoracoscopy is used after conventional pleural sampling is nondiagnostic. We perform simple rigid thoracoscopy after two or three thoracenteses and usually one pleural **biopsy** specimen are nondiagnostic (if the patient's clinical condition warrants further investigation). The use of...

...patients with EUO.

The diagnosis of mesothelioma depends foremost on histologic findings.[29] Obtaining definitive **biopsy** samples for the diagnosis of mesothehoma is a main indication for thoracoscopy. Boutin et al...

...densities (9%). One quarter of the patients required electrocautery or laser to lyse adhesions. Thoracoscopic **biopsy** specimens were positive in 150 of 153 (98%) mesothelioma cases. In contrast, the combined sensitivity of pleural cytologic study and closed needle **biopsy** was only 38%. Thoracoscopy provides equally good tissue samples for diagnosis of mesothehoma compared with...

...avoided.

Parenchymal Disease

Ultimately, one third of patients with diffuse lung disease will undergo open **biopsy** to establish a diagnosis. 32 Open lung **biopsy** has an operative mortality of 1.7% and risk for serious morbidity of 2.5% in selected patients.[14,33] Thoracoscopic lung **biopsy** has been proposed as an alternative to open **biopsy** when **bronchoscopic** transbronchial **biopsy** specimens are indeterminate. Thoracoscopy, as opposed to **bronchoscopy** , can obtain larger pieces of lung tissue under direct visualization. Early reports describe the thoracoscopic approach using forceps, electrocautery, or cup **biopsy** techniques. Boutin and coworker's[34] performed lung **biopsies** through a 7-mm rigid thoracoscope without video assistance in 75 patients with parenchymal lung...

...prolonged pneumothorax for 15 days. In a review of the literature, 36 nonvideoassisted thoracoscopic lung **biopsy** achieved a diagnosis in 90% of 968 cases of various etiologies. The highest diagnostic sensitivities...

...98%) and in diffuse malignant disease (90%).

VATS is now another alternative to open lung **biopsy** . Three nonrandomized studies have investigated the VATS approach for lung **biopsy** . Bensard and coworkers[37] retrospectively analyzed 22 consecutive patients with interstitial disease who underwent VATS lung **biopsy** and compared then with 21 control patients who underwent open **biopsy** . They concluded that VATS (1) provided equivalent specimen volume, (2) achieved equal diagnostic accuracy, and (3) reduced both the time for pleural drainage and the colleagues[38] **length** of hospital stay. Ferson and colleagues retrospectively compared 47 patients who underwent VATS lung **biopsy** with 28 historical control patients who underwent open wedge

biopsy via limited thoracotomy. The mean operative time was significantly longer in the VATS group (69...

...using their current VATS technique with their previous experience with patients who underwent thoracoscopic cup **biopsy** without video assistance. In 30 patients undergoing thoracoscopic cup **biopsy** , there were ten deaths (30%) and one prolonged air leak. Mean hospital stay was 16.6 days in this group. In contrast, 11 patients underwent a VATS lung **biopsy** , with only 1 death (9%) and a mean hospital stay of 8.2 days. However...

...groups were poorly matched and a strong selection bias existed against the non-VATS cup **biopsy** group. The cup **biopsy** group consisted of hospitalized patients with progressive respiratory insufficiency, most of whom required mechanical ventilation...

...the hospital for evaluation of stable lung disease.

The above studies suggest that VATS lung **biopsy** is an alternative to open **biopsy** . In agreement with others, 40 we believe that VATS lung **biopsy** is suitable for patients in stable condition who are not requiring mechanical ventilation. Ventilator-dependent patients should not undergo **biopsies** by the VATS approach because they typically cannot tolerate the change to a double-lumen...

...patients requiring mechanical ventilation in most cases, it is advisable to perform an open lung **biopsy** through an expeditious limited thoracotomy using minimal rib spreading.

A solitary pulmonary nodule (SPN) is a discrete nodule less than 3 cm in **diameter** that is completely surrounded by lung and is not associated with parenchymal disease or adenopathy been reported.[41] Overall, malignant **lesions** comprise 44% of all SPNS, and most (35%) are bronchogenic cancer.[43] The risk of...

...the SPN include observation, assessment by noninvasive imaging, cytologic or histologic investigation by transthoracic needle **biopsy** (TTNB) or **bronchoscopy** , and surgical resection. TTNB has a diagnostic sensitivity ranging from 43% to 97% for malignant **lesions** but is less effective in yielding a definitive benign diagnosis[46]. But, TRNB is complicated...

...false-negative rate in the presence of malignancy ranges from 3 to 11%.[47-49] **Bronchoscopy** is useful for larger central **lesions** but has low diagnostic yield, approximately 10%, for small peripheral **lesions** .[50,51] If malignancy or a definitive benign diagnosis has not been proved by these less invasive **procedures** , the SPN can be approached surgically.

Mack and coworkers[46] from three collaborative institutions, excised ...

...With the development of endostaplers and refinements in instrumentation, thoracic surgeons are also performing VATS **procedures** for many indications previously reserved for open thoracotomy.

The Video-Assisted Thoracic Surgery Study Group...

...48%), pleural effusions (19%), and pulmonary infiltrates (14%) were the most common indications for VATS **procedures** . **Procedures** performed most commonly were wedge resection 49%), pleural **biopsy** (17%), pleurodesis (17%), and lung **biopsy** (6%). Four hundred thirty-nine **procedures** (24%) required conversion to thoracotomy because of the need for more extensive resection (219), inability...

...of repeated thoracentesis, or closed tube thoracostomy.[52] More

aggressive surgical approaches include open drainage **procedures** , decortication, and thoracoplasty. Recently, thoracoscopy with repeated irrigation of the thoracic cavity has been described...

...have complete resolution after thoracoscopy, the empyema resolved in eight (66%) patients after open surgical **procedures** . Thoracoscopic debridement may provide valuable time to improve the clinical condition of debilitated patients until...talc poudrage (2.5 g USP administered) for the treatment of chronic pleural effusions. No **procedure** -related mortality or significant morbidity occurred. Ambulatory patients in stable condition required hospitalization for a...

...malignancy. Of the five patients who did not respond, three had the lung encased by **tumor** which prevented the complete elimination of fluid and expansion of the lung. Ohri et also...

...bleb resection and pleurodesis is 3.6% (mean follow-up, 9.1 years).[65]

Endoscopic **photocoagulation** by argon or neodymium: yttrium-aluminum-gamet (ND:YAG) lasers can be used as curative...

...to 86 months). Thoracoscopy and laser failed early in two patients; both patients had lesions **larger** than 2 cm. Three other patients developed a later recurrance of pneumothorax. Each required thoracotomy...bullous disease. 61

Pulmonary metastasectomy may favorably incluence survival in select patients with certain tumors.[**67** ,68] There are two patient populations that are considered for metastasectomy. The first group consists...

...metastatic disease is needed. The second group consists of those patients with a limited tumor **burden** who may achieve a survival benefit from metastasectomy. Currently, thoracotomy or median sternotomy are the...

...approaches.[67,69] Dowling et al[67] successfully performed VATS resection of select peripheral lesions **in** 72 patients by the use of an endostapler, laser, or both. The mean diameter **of** the resected lesions **was** 1.6 cm (range, 0.2 to 4.3 cm). An lesions **were** resected and each had a tumor- **free** margin of at least 1 cm. The mean duration of chest tube Placement and hospital...

...air leaks).

There are several limitations to the VATS approach, however. First, only peripheral lesions **are** accessible by this technique. Second, the operator cannot perform careful bimanual palpation of the lungs...

...Roth and coworkers[70] noted that 45% of patients with unflateral metastases present on preoperative **chest** computed tomography **were** found to have bilateral metastases present at median stemotomy. Confirmation of equivalent survival by randomized...

...the various surgical approaches for metastasectomy is required before the reported reduced morbidity and length **of** stay afforded by the thoracoscopic technique can be of significant benefit to the patient.

Emphysenmatous...

...limitations of the VATS approach. To ensure proper staging of the lung cancer, multiple biopsy **specimens** of hilar and mediastinal lymph nodes were obtained, in particular in those few patients who had not undergone a staging mediastinoscopy. This VATS technique also allowed for biopsy **specimens** of lymph node stations that are not readily accessible by mediastinoscopy. These stations include the operating time, intraoperative

blood loss, duration of chest tube drainage, length **of** hospital stay, or disabling postsurgical pain. More complications occurred in the thoracotomy group. Insufficient time...

...survival in each group. This study underscores the importance of not supplanting accepted open procedures **with** a VATS operation **because** of purported advantages and limited evidence of equivalence.

Other Operative Applications

Thoracoscopic esophagomyotomy is a...

...a VATS (15) or a laparoscopic (2) Heller myotomy. Two (11%) cases necessitated open procedures. **The** mean hospital stay was 3 days, the mean lower esophageal pressure was lowered from 32...

...21%) of the 14 patients with initial excellent or good results required a second procedure. **Long** -term outcome data are not reported.

Pericardial effusions, malignant or benign, can be addressed by...

...COMPLICATIONS

Morbidity

Known complications of thoracoscopy include bleeding, empyema, wound infection, prolonged air leak, tumor **seeding** at the entry site, and death.[7,11-14]It is difficult to summarize the...

...Who should perform thoracoscopy, pulmonologists or thoracic surgeons, is a primary topic of debate. Procedures **such** as diagnostic pleural biopsy **and** talc poudrage are currently being performed by select, experienced pulmonologists with a 90% sensitivity and high degree of safety.[14,58,85] Unquestionably, most therapeutic and operative **procedures** **are** the domain of the thoracic surgeon. It is imperative, therefore, that the pulmonologist and thoracic...

...of patients with suspected malignant effusion varies-recommendations range from observation to progressively invasive procedures **culminating** in a thoracotomy. Currently, thoracoscopy is employed after several attempts by conventional pleural sampling are...

...Thoracoscopy does increase the diagnostic yield for both benign and malignant disease. Preoperative patient characteristics (**such** as ... pleural malignancy by thoracoscopy is questionable until further therapeutic options are developed. Other measurable parameters **such** as improved comfort, number of hospital days, and cost need to be adequately studied.

VATS...

...for the diagnosis of benign and malignant pleural disease. It is useful for therapeutic procedures **such** as pleurodesis and uncomplicated empyema drainage. Current endoscopic **and** VATS techniques have the potential to limit morbidity and reduce hospital stays for major operations...

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19950900

29/5,K/57 (Item 37 from file: 149)
DIALOG(R)File 149:TGG Health&Wellness DB(SM)

01256911 SUPPLIER NUMBER: 13468226 (USE FORMAT 7 OR 9 FOR FULL TEXT)
The high price of bronchoscopy : **maintenance and repair of the flexible fiberoptic** bronchoscope .
Mehta, Atul C.; Curtis, Patricia S.; Scalzitti, Mary Lou; Meeker, David P.
Chest, v98, n2, p448(7)
August,
1990
PUBLICATION FORMAT: Magazine/Journal ISSN: 0012-3692 LANGUAGE: English
RECORD TYPE: Fulltext TARGET AUDIENCE: Professional
WORD COUNT: 3253 LINE COUNT: 00353

SPECIAL FEATURES: illustration; photograph; table; diagram; diagnostic image
DESCRIPTORS: **Bronchoscopy** --Diagnostic use; **Endoscopes** --Maintenance and repair
FILE SEGMENT: HI File 149

The high price of bronchoscopy : **maintenance and repair of the flexible fiberoptic** bronchoscope .

TEXT:

The practice of thoracic medicine was revolutionized by the advent of **bronchoscopy** . Killian[1] was given credit for performing the first **bronchoscopy** in 1897, in an attempt to remove a foreign body. In the late 1960s, Shigeto Ikeda[2] invented the flexible fiberoptic **bronchoscope** (FFB), initiating a new era in **bronchoscopic** evaluation. Fiberoptic **bronchoscopy** is now a simple, routine **procedure** commonly performed in the outpatient setting using local anesthesia by physicians without a surgical background...

...capabilities of the FFB is vast and ranges from mere airway examination to palliative laser **procedures** .[5-7] Design modifications and the development of accessories have paralleled today's increasing indications ...

The fiberoptic **bronchoscope** is composed of thousands of densely packed flexible glass fibers less than 10 [mu]m in **diameter** . A set of high precision objective and ocular lenses are placed at the distal and...

...These lenses are accurately aligned to provide adequate magnification of

the endobronchial tree. The distal **bending** portion of the FFB is connected by metal wire to the control lever located at...

...and the cost of even minor repairs may be extremely high. Adherence to proper maintenance **procedures** will maximize the life span of the instrument and minimize the repair costs.[8] Key...

...manipulation of the FFB, appropriate use of accessory instruments, and strict adherence to the recommended **procedures** for cleaning, disinfecting, sterilization,[9] storage, and shipping. The likelihood of damage to the FFB can also be reduced through proper patient **instruction** , sedation, positioning, and utilization of a bite block when appropriate.[8-10]

At our institution, we perform an average of 900 fiberoptic **bronchoscopies** each year. Besides the routine use of cytology brushes, double-lumen catheter brushes, and flexible forceps, 18- and 22-gauge **transbronchial needle aspiration** ,[11,12] catheter placement for endobronchial radiation therapy,[13] photodynamic therapy (PDT),[14] and neodymium...

...flexible scissors, various types of snares, and Fogarty catheters are often used.[15] All fiberoptic **bronchoscopies** are performed by one of six pulmonary special fellows under the direct supervision of one of the seven staff physicians. A **bronchoscopy** suite equipped with a fluoroscopy unit is available in the outpatient department as well as...

...A total of ten FFBs are available for use. Three registered nurses assist both outpatient **bronchoscopies** and laser **procedures** . Eight specially trained respiratory therapists assist the **bronchoscopist** in the hospital setting. The following article describes our experience with specific types of damage...

...on prevention of such problems.

Table 1 -- Areas of Potential Damage to the Flexible Fiberoptic **Bronchoscope**

Area of Potential Damage
Improper **handling**
Procedural
Transbronchial needle aspiration
Nd-YAG laser photoresection
Electrosurgery
Radiation
Use of lubricants
Patient related
Cleaning and maintenance
Ethylene...

...proximal portion of the flexible insertion tube and can be minimized by maintaining an adequate **distance** between the patient's face and the control unit of the FFB. This can be achieved by adjusting the **bronchoscopy** table to the proper height or through use of a stepstool by the **bronchoscopist** when the **procedure** is performed with the patient in a supine position. If the patient is sitting in a chair, this **distance** can be easily adjusted by stepping backwards. **Rotation** of the body of the scope should be performed by flexing or extending the wrist...

...allows maximal flexibility, the tubing is extremely vulnerable to trauma from the use of flexible **endoscopic** instruments. If this plastic tubing is perforated, fractured, or lacerated, liquids may seep into the...

...5). In our experience, this is a major drawback with the use of the immersible **bronchoscope** as its submersion into the cleaning solutions increases the likelihood that fluids will seep into...

...The proximal portion of the FFB is the most vulnerable area to such damage because **flexible instruments** impact on this portion of the tubing while negotiating the angulation. To prevent the damage...

...however, we do not have adequate experience with such FFBs to comment at this stage.

Transbronchial Needle Aspiration

The transbronchial aspiration needle (TBAN) for cytology and histology specimens has significantly increased the diagnostic yield of fiberoptic **bronchoscopy** .[11,12,16-18] However, if improperly used it may cause severe damage to the...test"[20] (described in detail in the owner's manual) should be performed after each **transbronchial needle aspiration** to rule out perforation of the channel. This will permit early identification of damage to...

...opinion the TBAN should be used only by or under the supervision of an experienced **bronchoscopist** .

One should be aware of the **diameter** of the working channel of the FFB being used. Accessories with a **diameter** equal to or larger than that of the working channel of the FFB should not...

...TBAN used to obtain histology specimens cannot be passed through the working channel of one **bronchoscope** (Olympus BF-1T20) because its 15-mm long metal needle will not negotiate the acute **angle** between the insertion port and the working channel of the FFB.[21,22]

Damaged **endoscopic** accessories such as forceps should be replaced rather than repaired due to the delicate nature...

...an important palliative therapy in the management of bronchogenic carcinoma and the benign unresectable endobronchial **lesion** .[15,23,24] The **procedure** can be performed either through the rigid **bronchoscope** or the FFB.[5,15,25] However, with the powerful capabilities of laser therapy comes...

...use of a highly combustible polyvinyl chloride (PVC) endotracheal tube, while performing Nd-YAG laser **procedure** through the FFB, further increases this risk.[27] While use of the FFB to perform such **procedures** is not contraindicated, extreme care should be taken to avoid the possibility of endobronchial ignition...

...possibility of combustion. The concentration of supplemental oxygen should not exceed 40 percent. If the **procedure** is being performed through a PVC endotracheal tube, the maximum possible **distance** should be maintained between its tip and the treatment site.[15] A low power density ...

...the heated metal tip of the noncontact laser fiber could damage the channel of the **bronchoscope** during its withdrawal (Fig 6). In our personal opinion, the safety of the bare laser...

...the FFB. It should be noted that manufacturers of the FFB have not included laser **procedures** as one of the indicated uses of the instrument and may not provide warranty repairs...

...laser-related damage to the instrument.

Electrosurgery

The role of electrosurgery performed via the flexible **endoscope** in the management of various gastrointestinal tract **lesions** is well established. In recent years there has been increasing interest in the application of this modality in the management of endobronchial **lesions** .[29-31] However, unlike flexible **endoscopes** , FFBs are not electrically grounded.[30] If the wire electrocautery loop inadvertently touches the tip of the FFB the current could ground through the FFB and the **endoscopist** , generating sparks at either end of the instrument. In the presence of a high concentration...

...than wire loop cautery in this regard.[31]

Radiation

Fluroscopy has added immensely to the **procedure** of fiberoptic **bronchoscopy** , especially while performing brushings,[33] transbronchial **biopsies** , **transbronchial needle aspiration** of peripheral nodules,[34,35] and localized bronchography. Excessive exposure of the FFB to radiation...might lead to grabbing or pulling the fiberscope by the patient. While the most common **method** of **insertion** is the transnasal approach, it may be necessary to use the transoral approach or to perform the **procedure** through the endotracheal tube.[9] A mouthpiece (bite guard) must be used during the latter...

...with damage to the fiber bundles (Figs 3 and 7). In addition, when performing fiberoptic **bronchoscopy** through the endotracheal tube, proper lubrication and appropriate matching of scope size to tube size...

...the distal portion of the FFB.[32]

CLEANING AND MAINTENANCE

Strict adherence to the recommended **procedures** for cleaning, disinfection, and sterilization must be employed as these instruments have limited tolerance for...

...1988).[20] Failure to use the venting cap correctly may result in rupture of the **bending** rubber when a vacuum is created during the sterilization **procedure** (Fig 8). Following gas sterilization the ETO cap must be removed to reseal the FFB...

...closure of the case lid. The ETO venting cap must be put on during long-**distance** transportation of the instrument.

FINANCIAL IMPACT OF FIBEROPTIC DAMAGE

To evaluate cost factors for a busy **bronchoscopy** service, we have reviewed our **bronchoscopy** repair records specifically for the rate of occurrence of preventable and unpreventable repairs over a...

...spent over this period to repair damaged FFBs. We do appreciate that the number of **endoscopic** examinations, the type of endobronchial **procedures** (laser, **TBNA** , etc), and the training of our pulmonary fellows impacted on our repair cost. However, reviewd...

...the FFB while closing the carrying case lid, or the patient biting on the fiberoptic **bronchoscope** . Only 13 percent of repairs, such as a frozen distal tip (distal tip fixed in one position that could not be maneuvered manually or by using proximal controls) or impaired **angle** control mechanism were considered unpreventable.

We examined the various manufacturers' **instruction** manuals and found that they contained explicit **directions** for prevention of several such complications. However, according to our own survey, only 11 percent of personnel involved with the **procedure** of FFB will familiarize themselves with the **instruction** manual. We believe that this manual is an underused resource for the education and training...

...should be readily available for reference and recommended at the beginning of training for fiberoptic **bronchoscopy** . In addition, information may need to be updated as new techniques are developed with **procedures** that differ from those described in the original manual.

Table 2 -- Summary of Flexible Fiberoptic **Bronchoscope** (FFB) Repair Cost at The Cleveland Clinic Foundation, January 1985 to June 1989(*1)

Types of Damage	Average Cost per Repair	Frequency	Type of Repair
Impaired **angle** control	$1,632	5	Unpreventable
Frozen distal tip [DDAG]	$2,300	1	Unpreventable

Damaged inner number of repairs: 42; total repair cost: $89,863.11; total number of **bronchoscopies** (including photodynamic therapy): 3,828; total number of Nd-YAG laser photoresections: 166; and preventable...

...percent. TBAN = transbronchial aspiration needle; ETO = ethylene oxide.

We speculate that the costs of a **bronchoscopy** service may be significantly reduced by instituting a proper care program. With emphasis on cost...

...span of the instrument and minimize the associated repair costs.

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DESCRIPTORS: **Bronchoscopy** --...

... **Endoscopes** --
19900800

29/5,K/58 (Item 1 from file: 98)
DIALOG(R)File 98:General Sci Abs/Full-Text

03035682 H.W. WILSON RECORD NUMBER: BGSI95035682 (USE FORMAT 7 FOR FULLTEXT)
The growing reality of virtual reality.
AUGMENTED TITLE: uses in science research and public education
Stevens, Jane Ellen
BioScience (BioScience) v. 45 (July/Aug. '95) p. 435-9
DOCUMENT TYPE: Feature Article
SPECIAL FEATURES: il ISSN: 0006-3568
LANGUAGE: English
COUNTRY OF PUBLICATION: United States
RECORD TYPE: Abstract; Fulltext RECORD STATUS: New record
WORD COUNT: 3972

ABSTRACT: The technology of virtual reality is contributing to scientific research and public education. The most familiar form of virtual reality involves the use of headpieces that display three-dimensional computerized

images, enabling viewers to examine a new world that changes as they shift the position of their heads. The National Library of Medicine has developed a **three - dimensional** " **Virtual** Human" that facilitates the study of anatomy and physiology. Virtual reality is also being used in molecular **modeling** , and **virtual** reality **images** are being used in biology classrooms to provide students with novel views of human organs and the interior of cells.

DESCRIPTORS:
Virtual reality

(USE FORMAT 7 FOR FULLTEXT)

...ABSTRACT: they shift the position of their heads. The National Library of Medicine has developed a **three - dimensional** " **Virtual** Human" that facilitates the study of anatomy and physiology. Virtual reality is also being used in molecular **modeling** , and **virtual** reality **images** are being used in biology classrooms to provide students with novel views of human organs...

TEXT:
... a way for future physicians to practice surgical techniques without having to advance their learning **curve** on humans. At this relatively early stage in its development, virtual reality's promises for...

...alter their brain physiologically?
Despite these problems, the component technologies that are being developed for **virtual** reality-- **three - dimensional** **images** presented on a two-dimensional computer screen using advanced databases and high-speed networking--are...

...that everything about the environment in virtual reality is fake. In augmented reality, the person **operating** the **system** interacts with something in the real world.) Although these technologies are principally used in medicine...

...biomedical community is no less revolutionary than virtual reality. Students are manipulating parts of the **three - dimensional** " **Virtual** Human," a program developed by the National Library of Medicine, on a computer screen to...
...dimensional computer graphics to simulate flying through a colon to look for cancerous polyps. During **endoscopic** surgery, surgeons are wearing 3-D glasses to see the inside of the abdomen in...Currently, the biomedical community is using the new technologies in four major ways:
to see **parts** of the **body** more accurately--for study, to make better diagnosis of disease, and to plan surgery in more detail
to obtain a more accurate picture of a **procedure** during surgery
to perform more types of surgery with the most noninvasive, accurate **methods** possible
to model interactions among molecules at a molecular level
The " **Virtual** Human" **three - dimensional** **model** of the human body was developed from magnetic resonance (MR), computer tomography (CT), and anatomical...

...the cadavers. The basic data have been massaged with Silicon Graphics technology so that any **part** of the **body** can be viewed, with or without skin, muscle, blood vessels, or bones. Viewers can fly...

...Winston-Salem, North Carolina, has developed what he calls a "virtual colonoscopy." In this new **procedure** , a CT scan takes pictures as video

instead of the snapshots provided by the previous...
...the colon's twists and turns to look for cancerous polyps. Vining has tested the **procedure** by viewing colons of approximately a dozen people, and he has plans to try it...

...Lucia Zamorano uses three-dimensional images derived from MR and CT scans to view brain **tumors** . As if endowed with Superman's X-ray vision, she can see an image of a **tumor** floating in the brain and turn the head image in all **directions** to choose the shortest, least damaging path.

Zamorano, who is director of computer-assisted surgery...

...Guided Technologies, a company in Boulder, Colorado. The sensor tracks surgical instruments. While excising a **tumor** deep in the brain, she watches the position of her surgical tools in a computer graphics **image** of the **patient** 's brain. This guided-imaging technology has been useful in more than 600 operations for patients with brain **tumors** , epilepsy, severe pain, Parkinson's disease, and serious obsessive-compulsive disorders.

"With this type of...

...surgery, we can treat a larger scope of patients," says Zamorano. "There are fewer inoperable **lesions** . We can excise **lesions** deeper in the brain and do less damage to surrounding tissues. Although the **preoperative planning** takes longer, the surgery takes less time. The patients recover sooner. The average stay after...

...way. In Boston, at Brigham and Women's Hospital, neurosurgeon and radiologist Ferenc Jolesz performs **biopsies** and Marvin Fried does **endoscopic** sinus surgery with a new MR machine produced by General Electric Medical **Systems** in Waukesha, Wisconsin. A surgeon **operates** on a patient who essentially lies in the holes of two metal doughnuts standing on...

...patient's head, he sees a real-time MR image of the inside of the **patient** --instead of an **image** that is a day or a week old--and the position of the tools. Currently...

...a traditional two-dimensional MR image; Jolesz eventually plans to use a three-dimensional imaging **system** .

Court Cutting, associate professor of plastic surgery at New York University Medical Center, has also...

...At this point, that type of guided-imaging technology does not lend itself to other **endoscopic procedures** , in which **operations** are done through small incisions in the body in which a miniature camera and surgical...

...dimensional displays are finding their way into the operating room. Since 1989, when the first **endoscopic procedure** was used to take out a patient's diseased gall bladder through a tiny incision in his abdomen, **endoscopic** surgeons have struggled with the problem of judging **distances** in two-dimensional video images.

Endoscopic surgeons in several US hospitals are using four types of 3-D glasses approved by...

...they are popping out from the video monitor. The surgeons have an easier time judging **distances** and can perform some operations more quickly.

DEVELOPERS OF MODELS

Three-dimensional imaging technologies are...electromagnetic transmitter that is tracked by a location sensor. When the person with the tracking **system** moves around to look at different sides of a molecule, for example, the computer senses...

...years ago Richard Greenberg, professor of planetary sciences and director of the Center for Image **Processing** in Education at the University of Arizona, founded a project to instruct teachers in image **processing** with funding from the National Science Foundation (NSF). Approximately 1000 teachers have taken five-day...

...audience will wear 3-D glasses, which will make it appear as if 15-foot **diameter** organelles are hanging over their heads. With special paddles, they will be able to rotate...

...continue dividing, filling the space with hovering cells.

VIRTUALLY AT HOME

The expansion of scientific **imaging** into **virtual** reality is still in its infancy. Some people expect that the cost of head-mounted...

...people could together explore the wonders of a cell, the inside of volcanoes, and the **depths** of the ocean with virtual reality. Such a group activity would provide the extra stimulation...

...of Illinois at Chicago.

Rob Fisher and colleagues at Carnegie Mellon's Studio for Creative **Imaging** are creating a **virtual** reality journey to the center of the cell that could be used in planetariums. Three...

1995

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Set      Items   Description
S1     1267374   METHOD?
S2     1048241   SYSTEM?
S3      427884   PROCEDURE?
S4     1033070   PROCESS?
S5       10781   VIDEOSCOP? OR BRONCOSCOP? OR BRONCHOSCOP? OR BRONCHISCOP? -
              OR ENDOSCOP? OR FLEXIBLE()(TOOL? OR INSTRUMENT? OR CYLINDER?)
S6           0   DC=(E7.230.220? OR E7.858.240?)
S7      750380   INSTRUCTION? OR DIRECTION? OR NAVIGATION?
S8       54351   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
              CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
              PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(MODEL? OR PLA-
              N? OR PATH? OR GEOMETR? OR MAP OR MAPPING OR MAPS)
S9       68283   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
              CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
              PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(IMAGE? ? OR I-
              MAGING OR ORIENTATION? OR CONFIGURATION? OR TRAJECT?)
S10       6404   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
              CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
              PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(CT OR CAT OR -
              TOMOGRAPH? OR MRI OR ULTRASO? OR MAGNETIC?()RESONAN?)
S11       3067   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
              CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
              PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(2()D OR 2DIME-
              NSION? OR 2()DIMENSION? OR TWODIMENS? OR TWO()DIMENSION?)
S12       5347   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
              CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
              PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(3()D OR 3DIME-
              NS? OR 3()DIMENS? OR THREEDIMEN? OR THREE()DIMEN?)
S13      19203   TBNA OR TRANSBRON?()NEEDLE?()ASPIRAT? OR BIOPS?
S14     856092   CHARACTERISTIC? OR PARAMETER? OR ROTATION?
S15     911574   DIAMETER? OR LENGTH? OR DISTANCE? OR DEPTH?
S16     590121   BEND? OR DEFLECT? OR CURV? OR ANGLE? ?
S17      46321   (ANATOM? OR BODY OR BODILY)(2N)(LANDMARK? OR SITE? OR TARG-
              ET? OR STRUCTURE? OR PART?) OR CARINA?
S18      87327   LESION? OR TUMOR? OR TUMOUR? OR TRACHEOBRONC?()TREE?
S19     395564   GUIDE? ? OR GUIDING OR MANIPULAT?
S20    1148178   HANDLE? ? OR HANDLING OR INSERT? OR OPERAT?
S21      50295   IC=A61B?
S22       9957   S1:S4 AND S5:S6
S23       6706   S22 AND S7:S12
S24       6609   S23 AND S14:S18
S25       2084   S24 AND S19:S20(5N)S5:S6
S26       1488   S25 AND S21
S27        726   S25:S26 AND S14:S18(5N)S7:S12
S28        513   S27 AND S1:S4(5N)S19:S20
S29        154   S28 AND S1:S4(5N)S7:S12
S30        124   S29 AND (S13 OR S21)
S31        154   S29:S30
S32        117   S31 AND S1:S4(5N)S5:S6
S33         79   S32 AND PY<2002
S34         79   IDPAT (sorted in duplicate/non-duplicate order)
? show files
File 348:EUROPEAN PATENTS 1978-2003/Dec W02
         (c) 2003 European Patent Office
File 349:PCT FULLTEXT 1979-2002/UB=20031225,UT=20031218
         (c) 2003 WIPO/Univentio
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34/5/2 (Item 2 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00468128 **Image available**
IMAGE GUIDED **SURGERY** SYSTEM
SYSTEME **CHIRURGICAL** GUIDE **PAR IMAGES**
Patent Applicant/Assignee:
KONINKLIJKE PHILIPS ELECTRONICS N V,
PHILIPS PATENTVERWALTUNG GMBH,
PHILIPS NORDEN AB,
Inventor(s):
KONEN Wolfgang,
SCHOLZ Martin,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9858593 A2 **19981230**
Application: WO 98IB798 19980525 (PCT/WO IB9800798)
Priority Application: WO 98IB798 19980525
Designated States: JP AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE
Main International Patent Class: **A61B-019/00**
International Patent Class: **A61B-001/04**
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 3699

English Abstract
An image **guided** surgery **system** comprises an **endoscope** (11) with an image pick-up apparatus and a position measuring **system** (10, 21) for measuring the position of the **endoscope** (11). A data processor (2) is arranged to **process** image data according to the measured position of the **endoscope** and derive combined image data from the **processed** image data and image information from the image pick-up apparatus. The **processed** image data are derived from said image data and said image information from the image pick-up apparatus and said measured position. For example the image data are CT or MRI images or the image data represent one or several **anatomical landmarks** in the **body** of a patient (12) to be examined.

French Abstract
Le **systeme** chirurgical **guide** par images de la presente invention comporte un **endoscope** (11) pourvu d'un dispositif de prise de vue et d'un **systeme** de mesure de la position (10, 21) permettant de mesurer la position de l' **endoscope** (11). Un **processeur** de donnees (2) est configure de facon a obtenir des donnees image combinees a partir des donnees image traitees et a obtenir des informations image a partir de l'appareil de prise de vue. A partir desdites donnees image, le **systeme** donne des donnees image traitees, et a partir de l'appareil de prise de vue et de ladite position mesuree, le **systeme** donne lesdites informations image. De telles donnees image sont des images de tomographie assistee par ordinateur ou des images d'IRM. Mais de telles donnees images peuvent egalement representer un ou plusieurs reperes dans l'anatomie du patient (12) a examiner.

34/5/6 (Item 6 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00172516
INTERNAL ENVIRONMENT SIMULATOR SYSTEM
SYSTEME **DE SIMULATION D'UN ENVIRONNEMENT INTERNE**
Patent Applicant/Assignee:
HON David Clinton,
Inventor(s):
HON David Clinton,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9005971 A1 **19900531**
Application: WO 89US4690 19891019 (PCT/WO US8904690)
Priority Application: US 8812 19881114
Designated States: AT AU BE BR CH DE DK FI FR GB HU IT JP KP LU NL NO SE SU
Main International Patent Class: G09B-023/28
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 9669

English Abstract
A medical investigative **system** in which a person interacts with the **system** to interject information that is utilized by the **system** to establish non-restricted environmental modeling of the realities of surrogate conditions to be encountered with invasive or semi-invasive **procedures** . This is accomplished by video display (54) of simulated internal conditions (57) that appear life-like, as well as by display of monitor data including, for example, blood pressure, respiration, heart beat rate and the like.

French Abstract
Le **systeme** d'investigation medicale permet d'etablir une interaction entre une personne et le **systeme** pour emettre des informations qui sont utilisees par le **systeme** en vue d'etablir un modelage de l'environnement non restreint des realites d'etats subroges que l'on rencontre avec des **procedures** invasives ou semi-invasives. Ceci est effectue en affichant sur un affichage video (54) des etats internes simules (57) qui apparaissent comme dans la realite, ainsi que par affichage de donnees de controle telles que la pression du sang, la respiration, le rythme cardiaque et autre.

34/5/13 (Item 13 from file: 348)
DIALOG(R)File 348:EUROPEAN PATENTS

01034730
Image display
Bildanzeige
Affichage d'image
PATENT ASSIGNEE:
PICKER INTERNATIONAL, INC., (571721), 595 Miner Road, Cleveland, Ohio 44143, (US), (Applicant designated States: all)
INVENTOR:
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LEGAL REPRESENTATIVE:
van der Veer, Johannis Leendert et al (78072), International Octrooibureau B.V., Prof. Holstlaan 6, 5656 AA Eindhoven, (NL)
PATENT (CC, No, Kind, Date): EP 919956 A2 990602 (Basic)
EP 919956 A3 010314
APPLICATION (CC, No, Date): EP 98308071 981005;
PRIORITY (CC, No, Date): US 980169 971126
DESIGNATED STATES: AT; BE; CH; CY; DE; DK; ES; FI; FR; GB; GR; IE; IT; LI; LU; MC; NL; PT; SE
EXTENDED DESIGNATED STATES: AL; LT; LV; MK; RO; SI
INTERNATIONAL PATENT CLASS: G06T-015/10

ABSTRACT EP 919956 A2
An interactive virtual **endoscopy system** 10 includes a CT scanner 12 or other non-invasive examination apparatus which examines an interior region of a subject 14 in an examination region 16 and generates data indicative thereof. The data is stored in a volume image data memory 20. Using a sequence generating computer 22, a human operator 24 generates a sequence of sphere-mappable panoramic views of selected portions of the CT data along a viewpath in the patient 14. The sequence generating computer includes a view renderer 182 for rendering a plurality of views which in total cover the entire visual space about a viewpoint on the viewpath within the subject. A view compositor combines the plurality of views into a full image covering the entire visual space about the viewpoint. The sequence is transferred to a server which **processes** the data and makes it available for remote access. Over a local area network (LAN), the data is selectively transferred, based on the commands of a remote human viewer, to a remote viewing computer 34. The data is decompressed and mapped into a spherical image for display on a remote display screen 36.

Viewers of the sequence of spherical images have the liberty to turn at will and view in any **direction** from a particular viewpoint instead of being constrained to a look-forward path. In this way. viewers retain the sense of order and space which a look-forward series provides but with the added capability to investigate completely a space from any given viewpoint.
ABSTRACT WORD COUNT: 253
NOTE:
Figure number on first page: 1

LEGAL STATUS (Type, Pub Date, Kind, Text):

Search Report:	010314 A3	Separate publication of the search report
Application:	990602 A2	Published application (A1with Search Report ;A2without Search Report)
Assignee:	031203 A2	Transfer of rights to new applicant: Koninklijke Philips Electronics N.V. (4509061)

Groenewoudseweg 1 5621 BA Eindhoven NL

Change:	020724 A2	Designated contracting states changed 20020605
Change:	020102 A2	Designated contracting states changed 20011114
Examination:	011031 A2	Date of request for examination: 20010906
Assignee:	010418 A2	Transfer of rights to new applicant: Marconi Medical Systems, Inc. (2915231) 595 Miner Road Highland Heights, Ohio 44143 US
Change:	020626 A2	Legal representative(s) changed 20020507
Assignee:	030820 A2	Transfer of rights to new applicant: Philips Medical Systems (Cleveland), Inc. (3997830) 595 Miner Road Cleveland, Ohio 44143 US

LANGUAGE (Publication,Procedural,Application): English; English; English

FULLTEXT AVAILABILITY:

Available Text	Language	Update	Word Count
CLAIMS A	(English)	9922	665
SPEC A	(English)	9922	7732
Total word count - document A			8397
Total word count - document B			0
Total word count - documents A + B			8397

34/5/14 (Item 14 from file: 348)
DIALOG(R)File 348:EUROPEAN PATENTS

01003313
ENDOSCOPIC SYSTEM
ENDOSKOPISCHES SYSTEM
SYSTEME ENDOSCOPIQUE
PATENT ASSIGNEE:
Karl Storz GmbH & Co. KG, (2904000), Mittelstrasse 8, 78532 Tuttlingen, (DE), (Proprietor designated states: all)
INVENTOR:
IRION, Klaus, M., Heudorfer Strasse 38, D-78576 Liptingen, (DE)
WENZLER, Hartmut, Leerstrasse 26, D-78665 Frittlingen, (DE)
SCHWARZ, Peter, Eugenstrasse 9, D-78532 Tuttlingen, (DE)
LEGAL REPRESENTATIVE:
Popp, Eugen, Dr. (38669), Dr. Munich & Kollegen c/o MEISSNER, BOLTE & PARTNER Widenmayerstrasse 48, 80538 Munchen, (DE)
PATENT (CC, No, Kind, Date): EP 975257 A2 000202 (Basic)
EP 975257 B1 030226
WO 98046120 981022
APPLICATION (CC, No, Date): EP 98930668 980416; WO 98EP2224 980416
PRIORITY (CC, No, Date): DE 19715951 970416
DESIGNATED STATES: DE; FR; GB; IT
INTERNATIONAL PATENT CLASS: **A61B-001/04**
CITED PATENTS (EP B): EP 639349 A; WO 96/25881 A; WO 97/19440 A; US 5704897 A
CITED PATENTS (WO A): US 5503320 A ; EP 495351 A ; US 5253647 A ; US 5383454 A ; US 5417210 A ;
NOTE:
No A-document published by EPO
LEGAL STATUS (Type, Pub Date, Kind, Text):

Examination:	000524	A2	Date of request for examination:
Application:	20000202	A2	Published application without search report
Change:	031210	B1	Legal representative(s) changed 20031024
Change:	030205	A2	Designated contracting states changed 20021213
Examination:	000607	A2	Date of request for examination: 19991015
Examination:	010725	A2	Date of dispatch of the first examination report: 20010608
Grant:	030226	B1	Granted patent
Application:	990324	A2	International application (Art. 158(1))
Assignee:	20000308	A2	Transfer of rights to new applicant: Karl Storz GmbH & Co. KG (2904000) Mittelstrasse 8 78532 Tuttlingen DE
Examination:	20000202	A2	Date of request for examination: 19991015

LANGUAGE (Publication,Procedural,Application): German; German; German
FULLTEXT AVAILABILITY:

Available Text	Language	Update	Word Count
CLAIMS B	(English)	200309	1724
CLAIMS B	(German)	200309	1416
CLAIMS B	(French)	200309	1691
SPEC B	(German)	200309	2555

Total word count - document A 0
Total word count - document B 7386
Total word count - documents A + B 7386

US006656110B1

(12) **United States Patent**
Irion et al.

(10) **Patent No.: US 6,656,110 B1**
(45) **Date of Patent: Dec. 2, 2003**

(54) **ENDOSCOPIC SYSTEM**

(75) Inventors: **Klaus Irion**, Liptingen (DE); **Hartmut Wenzler**, Frittlingen (DE); **Peter Schwarz**, Tuttlingen (DE)

(73) Assignee: **Karl Storz GmbH & Co. KG** (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/403,148**

(22) PCT Filed: **Apr. 16, 1998**

(86) PCT No.: **PCT/EP98/02224**

§ 371 (c)(1),
(2), (4) Date: **Jan. 10, 2000**

(87) PCT Pub. No.: **WO98/46120**

PCT Pub. Date: **Oct. 22, 1998**

(30) **Foreign Application Priority Data**

Apr. 16, 1997 (DE) 197 15 951

(51) **Int. Cl.**^{7} **A61B 1/00**

(52) **U.S. Cl.** **600/117**; 600/103; 600/109; 606/130; 348/75

(58) **Field of Search** 600/102, 103, 600/114, 117, 118, 100, 160, 166, 170, 171, 417, 429; 348/45, 74; 606/130

(56) **References Cited**

U.S. PATENT DOCUMENTS

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5,383,454 A		1/1995	Bucholz	
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FOREIGN PATENT DOCUMENTS

EP	0 495 351 B1	7/1992
EP	0 639 349 A2	2/1995
EP	0 672 389 A2	9/1995
WO	WO 96/25881	8/1996
WO	WO 97/19440	5/1997
WO	WO 98/46120	10/1998

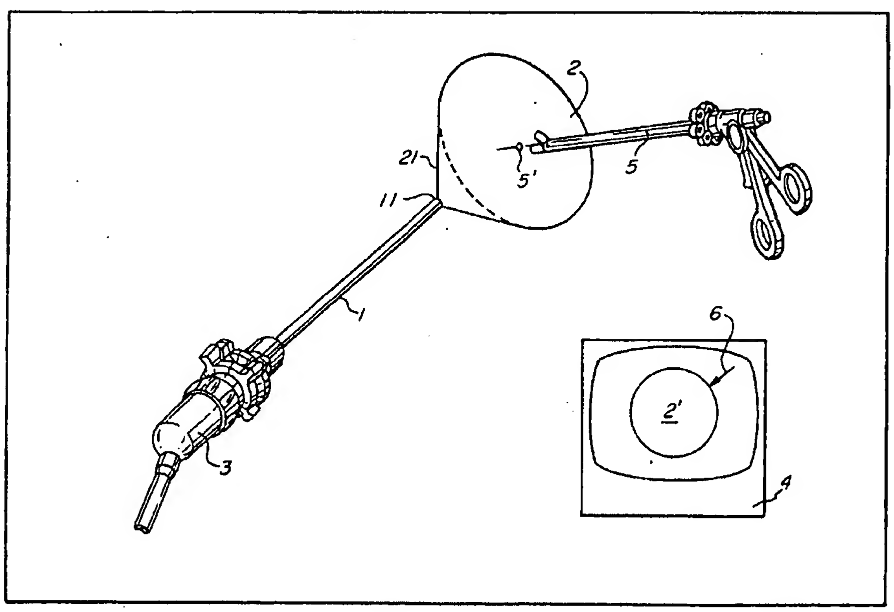
* cited by examiner

Primary Examiner—John Mulcahy
(74) *Attorney, Agent, or Firm*—St. Onge Steward Johnston & Reens LLC

(57) **ABSTRACT**

An endoscope system includes position sensors which detect not only the position, but also the orientation, of both an endoscope (or endoscopes) and at least one instrument. The endoscope system includes an assessment and control unit which displays symbols which indicate, in addition to the position, the orientation of the instrument or instruments and possibly of the endoscopes relative to a displayed image.

67 Claims, 5 Drawing Sheets



34/5/21 (Item 21 from file: 348)
DIALOG(R)File 348:EUROPEAN PATENTS

00823401
STEREOSCOPIC ENDOSCOPE SYSTEM **AND TV IMAGE PICKUP** SYSTEM **FOR THE** ENDOSCOPE
STEREOSKOPISCHES ENDOSKOP UND TV-BILDAUFNAHMESYSTEM FUR DAS ENDOSKOP
SYSTEME **D'** ENDOSCOPE **STEREOSCOPIQUE ET** SYSTEME **DE CAPTAGE D'IMAGE TELEVISUELLE**

PATENT ASSIGNEE:
Olympus Optical Co., Ltd., (259720), 43-2, 2-chome, Hatagaya Shibuya-ku, Tokyo 151-0072, (JP), (Proprietor designated states: all)

INVENTOR:
NAKAMURA, Shinichi, 1-5-302, Owadamachi 7-chome, Hachioji-shi, Tokyo 192, (JP)

LEGAL REPRESENTATIVE:
Kack, Jurgen et al (93671), Kahler Kack Mollekopf Patentanwalte Vorderer Anger 239, 86899 Landsberg, (DE)

PATENT (CC, No, Kind, Date): EP 841586 A1 980513 (Basic)
EP 841586 A1 981202
EP 841586 B1 030416
WO 96037796 961128

APPLICATION (CC, No, Date): EP 96915208 960521; WO 96JP1343 960521
PRIORITY (CC, No, Date): JP 95125305 950524
DESIGNATED STATES: DE; FR; GB; NL
INTERNATIONAL PATENT CLASS: G02B-023/26
CITED PATENTS (EP B): WO 90/14040 A; WO 92/19008 A; DE 4405102 A; JP 4093912 A; JP 4353818 A; JP 5341207 A; JP 6059199 A; JP 6194580 A; JP 6202006 A; JP 6254046 A; JP 60088924 A; JP 62054215 A; JP 63304221 A

ABSTRACT EP 841586 A1
An armor (111a) of a scope unit (131) and a diaphragm (123) are arranged to be mutually freely turnable. The shape of an outer section (123c) of the diaphragm (123) and the shape of the inside of a scope joint (130a) of a TV camera unit (130) substantially agree with each other, and the outer section (123c) of the diaphragm (123) and the inside of the scope joint (130a) engage with each other. In a state in which the outer section (123c) of the diaphragm (123) and the inside of the scope joint (130a) are engaged with each other, a ring screw (133) is meshed with a thread (130b) so that the scope unit (131) and TV camera unit (130) will unitedly be joined with each other. At this time, since the outer section (123c) of the diaphragm (123) is engaged with the scope joint (130a), the diaphragm and TV camera unit can be turned relative to an objective optical **system** (119) and relay optical **system** (121) with the optical axis of the relay optical **system** (121) as an axis of turning. Moreover, a liquid-crystal shutter 124 in the TV camera unit (130) has two interceptive areas (124a, 124b) which can be switched temporally alternately. The interceptive areas (124a, 124b) intercept one of two light beams passing through either of aperture stops (123a, 123b).
ABSTRACT WORD COUNT: 225

NOTE:
Figure number on first page: 4

LEGAL STATUS (Type, Pub Date, Kind, Text):

Examination:	000614	A1	Date of dispatch of the first examination report: 20000428
Application:	970326	A1	International application (Art. 158(1))
Grant:	030416	B1	Granted patent
Change:	021002	A1	Legal representative(s) changed 20020814
Application:	980513	A1	Published application (A1with Search Report

;A2without Search Report)

Examination: 980513 A1 Date of filing of request for examination: 970528

Search Report: 981202 A1 Drawing up of a supplementary European search report: 981019

LANGUAGE (Publication,Procedural,Application): English; English; Japanese

FULLTEXT AVAILABILITY:

Available Text	Language	Update	Word Count
CLAIMS A	(English)	199820	3297
CLAIMS B	(English)	200316	723
CLAIMS B	(German)	200316	649
CLAIMS B	(French)	200316	908
SPEC A	(English)	199820	9684
SPEC B	(English)	200316	9644
Total word count - document A			12984
Total word count - document B			11924
Total word count - documents A + B			24908

34/5/32 (Item 32 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00841105 **Image available**
APPARATUS AND METHOD **FOR CALIBRATING AN** ENDOSCOPE
APPAREIL ET PROCEDE PERMETTANT DE CALIBRER UN ENDOSCOPE
Patent Applicant/Assignee:
CBYON INC, 2295 E. Bayshore Road, Suite 101, Palo Alto, CA 94303, US, US (Residence), US (Nationality)
Inventor(s):
KHADEM Rasool, 2456 West Bayshore, Apt. #6, Palo Alto, CA 94303, US,
Legal Representative:
DEHLINGER Peter J (et al) (agent), Iota Pi Law Group, Post Office Box 60850, Palo Alto, CA 94306-0850, US,
Patent and Priority Information (Country, Number, Date):
Patent: WO 200174267 A1 **20011011** (WO 0174267)
Application: WO 2001US10513 20010330 (PCT/WO US0110513)
Priority Application: US 2000193209 20000330
Designated States: AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CO CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG UZ VN YU ZA ZW
(EP) AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE TR
(OA) BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG
(AP) GH GM KE LS MW MZ SD SL SZ TZ UG ZW
(EA) AM AZ BY KG KZ MD RU TJ TM
Main International Patent Class: **A61B-019/00**
International Patent Class: **A61B-001/00** ; **A61B-005/06** ; G06T-005/00
Publication Language: English
Filing Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 9013

English Abstract
An apparatus for use in calibrating lens position and field of view in an **endoscope** is disclosed. The apparatus includes tracking elements mounted at fixed positions on the **endoscope** 's shaft, a holder providing an object or pattern to be viewed by the **endoscope** , when the **endoscope** is placed in the holder, and positional elements mounted on the holder at known positions. A processor in the apparatus operates to determine the positions of the tracking and positional elements, with the **endoscope** shaft received in the holder **guide** , and calculate from the determined positions, the coordinates of the **endoscope** lens with respect to the tracking elements, and the field of the view of the lens. Also disclosed is a calibration **method** which employs the apparatus.

French Abstract
L'invention concerne un appareil permettant de calibrer la position de la lentille et l' **angle** de champ d'un **endoscope** . Cet appareil comporte des elements de localisation montes sur des positions fixes de la tige de l' **endoscope** , un support contenant un objet destine a etre visualise par l' **endoscope** lorsque ce dernier est place dans le support et des elements de position montes sur des positions connues du support. Un **processeur** situe dans l'appareil permet de determiner les positions des elements de localisation et de position, la tige de l' **endoscope** etant fichee dans la voie de guidage du support, et calcule, a partir des positions determinees, les coordonnees de la lentille de l' **endoscope**

par rapport aux elements de localisation et l' **angle** de champ de la lentille. L'invention concerne egalement un procede de calibrage qui utilise cet appareil.

Legal Status (Type, Date, Text)
Publication 20011011 A1 With international search report.
Examination 20011220 Request for preliminary examination prior to end of 19th month from priority date

34/5/33 (Item 33 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00841104 **Image available**
APPARATUS AND METHOD **FOR CALIBRATING AN** ENDOSCOPE
APPAREIL ET PROCEDE PERMETTANT D'ETALONNER UN ENDOSCOPE
Patent Applicant/Assignee:
THE BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY, Stanford, CA 94305, US, US (Residence), US (Nationality)
Inventor(s):
SHAHIDI Ramin, 300 Third Street, #917, San Francisco, CA 94107, US,
EPITAUX Marc, 231 Winslow Street, Redwood City, CA 94063, US,
Legal Representative:
DEHLINGER Peter J (et al) (agent), Iota Pi Law Group, P.O. Box 60850, Palo Alto, CA 94306-0850, US,
Patent and Priority Information (Country, Number, Date):
Patent: WO 200174266 A1 **20011011** (WO 0174266)
Application: WO 2001US10264 20010330 (PCT/WO US0110264)
Priority Application: US 2000193209 20000330
Designated States: AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CO CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG UZ VN YU ZA ZW
(EP) AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE TR
(OA) BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG
(AP) GH GM KE LS MW MZ SD SL SZ TZ UG ZW
(EA) AM AZ BY KG KZ MD RU TJ TM
Main International Patent Class: **A61B-019/00**
International Patent Class: **A61B-001/00** ; **A61B-005/06** ; G06T-005/00; G06T-015/20
Publication Language: English
Filing Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 9093

English Abstract
An apparatus for use in calibrating lens position and field of view in an **endoscope** is disclosed. The apparatus includes tracking elements mounted at fixed positions on the **endoscope** 's shaft, a holder providing an object or pattern to be viewed by the **endoscope** , when the **endoscope** is placed in the holder, and positional elements mounted on the holder at known positions. A processor in the apparatus operates to determine the positions of the tracking and positional elements, with the **endoscope** shaft received in the holder **guide** , and calculate from the determined positions, the coordinates of the **endoscope** lens with respect to the tracking elements, and the field of the view of the lens. Also disclosed is a calibration **method** which employs the apparatus.

French Abstract
La presente invention concerne un appareil destine a etalonner la position d'une lentille et le champ de vision d'un **endoscope** . Cet appareil comprend des elements de suivi montes a des positions fixes sur l'axe de l' **endoscope** , un support permettant de visionner un objet ou un dessin a l'aide de cet **endoscope** , lorsque ce dernier est place sur ce support, et des elements de position montes sur ce support a des positions connues. Un **processeur** situe dans l'appareil fonctionne de facon a determiner les positions des elements de suivi et de position,

avec l'axe de l' **endoscope** recu dans le **guide** support, et a calculer a partir des positions determinees, les coordonnees de la lentille de l' **endoscope** par rapport aux elements de suivi, et le champs de vision de cette lentille. Cette invention concerne aussi un procede d'etalonnage au moyen de cet appareil.

Legal Status (Type, Date, Text)
Publication 20011011 A1 With international search report.
Examination 20020103 Request for preliminary examination prior to end of 19th month from priority date

34/5/44 (Item 44 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00756319 **Image available**
MEDICAL POSITIONING SYSTEM
SYSTEME **DE POSITIONNEMENT MEDICAL**
Patent Applicant/Assignee:
ELBIT SYSTEMS LTD, P.O. Box 359, 31053 Haifa, IL, IL (Residence), IL (Nationality)
Inventor(s):
STROMMER Gera, 33a Soroka Street, 34759 Haifa, IL
EICHLER Uzi, 12 Zivoni Street, 34657 Haifa, IL
Legal Representative:
KORAKH Eliav, Borochov, Korakh, Eliezri & Co., 15th Floor, Clal Atidim Tower, P.O. Box 58100, 61580 Tel Aviv, IL
Patent and Priority Information (Country, Number, Date):
Patent: WO 200069335 A1 **20001123** (WO 0069335)
Application: WO 2000IL279 20000518 (PCT/WO IL0000279)
Priority Application: US 99314474 19990518
Designated States: AE AG AL AM AT AT (utility model) AU AZ BA BB BG BR BY CA CH CN CR CU CZ CZ (utility model) DE DE (utility model) DK DK (utility model) DM DZ EE EE (utility model) ES FI FI (utility model) GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KR (utility model) KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SK (utility model) SL TJ TM TR TT TZ UA UG UZ VN YU ZA ZW
(EP) AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE
(OA) BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG
(AP) GH GM KE LS MW MZ SD SL SZ TZ UG ZW
(EA) AM AZ BY KG KZ MD RU TJ TM
Main International Patent Class: **A61B-005/05**
Publication Language: English
Filing Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 11339

English Abstract
System (100) includes a position, and orientation processor (102), a super imposing processor (104), a sensor interface (106), a main sensor (110), an auxiliary sensor (112), a 3D electromagnetic field generator (108), an image interface (116), a3D database (120), and a display unit (114). It is noted that **system** (100) can include additional 3D electromagnetic field generators.

French Abstract
L'invention concerne un **systeme** (100) comprenant un **processeur** de position et d'orientation (102), un **processeur** en superposition (104), une interface de detection (106), un capteur principal (110), un capteur auxiliaire (112), un generateur de champ electromagnetique 3D (108), une interface d'image (116), une base de donnees 3D (120) et une unite d'affichage (114). Il est a relever que le **systeme** (100) peut comprendre des generateurs de champ magnetique 3D supplementaires.

Legal Status (Type, Date, Text)
Publication 20001123 A1 With international search report.
Publication 20001123 A1 Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

Claim Mod	20010208	Later publication of amended claims under Article 19 received: 20001211
Examination	20010308	Request for preliminary examination prior to end of 19th month from priority date

34/5/47 (Item 47 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00738477 **Image available**
METHOD **AND** **APPARATUS** **FOR** **PERFORMING** **MINIMALLY** **INVASIVE** **SURGICAL** PROCEDURES
PROCEDE ET APPAREIL PERMETTANT DE REALISER DES INTERVENTIONS CHIRURGICALES A EFFRACTION MINIMALE

Patent Applicant/Assignee:
COMPUTER MOTION INC, 130-B Cremona, Goleta, CA 93117, US, US (Residence), US (Nationality)
Inventor(s):
WANG Yulun, 370 Vereda Leyenda, Goleta, CA 93117, US
UECKER Darrin, 3048 Foothill, Santa Barbara, CA 93105, US
LABY Keith, 220 Santa Rosa, Santa Barbara, CA 93109, US
WILSON Jeff, 1300 Portesuello, Santa Barbara, CA 93105, US
JORDAN Charles, 2431 Calle Galicia, Santa Barbara, CA 93109, US
WRIGHT James, 319 Santa Cruz Boulevard, Santa Barbara, CA 93109, US
GHODOUSSI Modjtaba, 602 Foxen Drive, Santa Barbara, CA 93105, US
Legal Representative:
YORKS Ben J, Irell & Manella LLP, Suite 400, 840 Newport Center Drive, Newport Beach, CA 92660, US

Patent and Priority Information (Country, Number, Date):
Patent: WO 200051486 A1 **20000908** (WO 0051486)
Application: WO 2000US5351 20000228 (PCT/WO US0005351)
Priority Application: US 99262134 19990303
Designated States: AE AL AM AT AU AZ BA BB BG BR BY CA CH CN CR CU CZ DE DK DM EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG UZ VN YU ZA ZW
(EP) AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE
(OA) BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG
(AP) GH GM KE LS MW SD SL SZ TZ UG ZW
(EA) AM AZ BY KG KZ MD RU TJ TM
Main International Patent Class: **A61B-001/06**
International Patent Class: **A61B-006/00**
Publication Language: English
Filing Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 22693

English Abstract
This invention is a surgical **system** (10) that may include a remotely controlled surgical instrument. The surgical instrument may be coupled to a tool driver (1602) that can spin, and actuate the instrument. The instrument may include an actuator rod that is coupled to an end effector (1710), and detachably connected to a push rod (1654). The push rod (1836) can move relative to the handle to actuate the end effector. The end effector may include a fixture that conforms to the shape of a needle (1712). The handle (1812) can be secured to the tool driver by inserting pins into corresponding slots that are located on both the instrument and the tool driver. The instrument can be controlled by an operator through a pair of handles (1806). Each handle may be mechanically balanced by a counterweight. The surgical **system** may also include a touch pad (1808) that allows the operator to enter **parameters** of the **system** .

French Abstract

L'invention concerne un **systeme** (10) chirurgical pouvant comprendre un instrument chirurgical commande a **distance** . L'instrument chirurgical peut etre couple a un organe d'entrainement (1602) d'outil capable d'imprimer une **rotation** a l'instrument et de l'actionner. L'instrument peut comprendre une tige d'actionnement couplee a un organe effecteur (1710) et reliee detachable a une tige (1654) de poussee. La tige (1836) de poussee peut se deplacer par rapport a la poignee pour actionner l'organe effecteur. L'organe effecteur peut comprendre un montage adapte a la forme d'une aiguille (1712). On peut fixer la poignee (1812) a l'organe d'entrainement d'outil en introduisant des broches dans des fentes correspondantes situees sur l'instrument et sur l'organe d'entrainement d'outil. L'instrument peut etre commande par un operateur au moyen de deux poignees (1806). Chaque poignee peut etre mecaniquement equilibre par un contrepoids. Le **systeme** chirurgical peut egalement comprendre un dispositif de telecommande (1808) qui permet a l' **operateur** d'entrer les parametres du **systeme** .

Legal Status (Type, Date, Text)

Publication	20000908 A1	With international search report.
Publication	20000908 A1	Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

34/5/50 (Item 50 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00568733 **Image available**
VIRTUAL ENDOSCOPY **WITH IMPROVED** IMAGE **SEGMENTATION AND** LESION **DETECTION**
SYSTEME **AMELIORE D'** ENDOSCOPIE **VIRTUELLE A SEGMENTATION DES IMAGES ET DETECTION DES** LESIONS
Patent Applicant/Assignee:
WAKE FOREST UNIVERSITY,
VINING David J,
HUNT Gordon W,
AHN David K,
STELTS David R,
GE Yaorong,
HEMLER Paul F,
SALIDO Tiffany W,
Inventor(s):
VINING David J,
HUNT Gordon W,
AHN David K,
STELTS David R,
GE Yaorong,
HEMLER Paul F,
SALIDO Tiffany W,
Patent and Priority Information (Country, Number, Date):
Patent: WO 200032106 A1 **20000608** (WO 0032106)
Application: WO 99US28030 19991124 (PCT/WO US9928030)
Priority Application: US 98109966 19981125
Designated States: AE AL AM AT AU AZ BA BB BG BR BY CA CH CN CR CU CZ DE DK DM EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW GH GM KE LS MW SD SL SZ TZ UG ZW AM AZ BY KG KZ MD RU TJ TM AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG
Main International Patent Class: **A61B-005/05**
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 13993

English Abstract
A **system** , and computer implemented **method** are provided for interactively displaying three-dimensional structures. Three-dimensional volume data (34) is formed from a series of two-dimensional images (33) representing at least one physical property associated with the three-dimensional structure, such as a body organ having a lumen. A wire frame model of a selected region of interest is generated (38b). The wireframe model is then deformed or reshaped to more accurately represent the region of interest (40b). Vertices of the wire frame model may be grouped into regions having a **characteristic** indicating abnormal structure, such as a **lesion** . Finally, the deformed wire frame model may be rendered in an interactive three-dimensional display.

French Abstract
L'invention porte sur un **systeme** et un procede mis en oeuvre par ordinateur et assurant la presentation interactive de structures en trois dimensions. On forme un volume tridimensionnel de données (34) a partir

d'une serie d'images (33) bidimensionnelles representant au moins une propriete physique associee a la structure tridimensionnelle telle qu'un organe corporel presentant une lumiere. On constitue (38b) ensuite un modele filaire d'une zone d'interet selectionnee. Ledit modele est alors deforme ou reforme pour representer plus exactement la zone (406) d'interet. Les sommets du modele filaire peuvent etre groupes en zones presentant une caracteristique indiquant une structure anormale, par exemple une **lesion** . Finalement le modele filaire deforme peut etre rendu sur un ecran interactif en trois dimensions.

34/5/56 (Item 56 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00511901 **Image available**
IMAGE-GUIDED THORACIC THERAPY AND APPARATUS THEREFOR
THERAPIE THORACIQUE GUIDEE PAR IMAGE ET APPAREIL ASSOCIE
Patent Applicant/Assignee:
BIOSENSE INC,
Inventor(s):
ACKER David E,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9943253 A1 **19990902**
Application: WO 98US13736 19980702 (PCT/WO US9813736)
Priority Application: US 9830241 19980225
Designated States: AL AM AT AU AZ BA BB BG BR BY CA CH CN CU CZ DE DK EE ES FI GB GE GH GM GW HR HU ID IL IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT UA UG UZ VN YU ZW GH GM KE LS MW SD SZ UG ZW AM AZ BY KG KZ MD RU TJ TM AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN ML MR NE SN TD TG
Main International Patent Class: **A61B-005/00**
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 6192

English Abstract
A probe (20) such as an **endoscope** equipped with a **biopsy** needle is guided to a target in or adjacent to the respiratory **system** . The position of the probe is monitored and a representation (26') of the probe is superposed on a previously acquired image of the respiratory **system** and adjacent tissues. Artifacts caused by motion due to respiration are suppressed by monitoring the respiratory state of the patient and acquiring the probe position when the respiratory state of the patient is equal to the respiratory state of the **patient** during **image** capture.

French Abstract
L'invention concerne une sonde (20), telle qu'un **endoscope** , equipee d'une aiguille a ponction- **biopsie** guidee vers une cible dans ou adjacente a un **systeme** respiratoire. La position de la sonde est surveillee et une representation (26') de la sonde est superposee sur une image deja acquise du **systeme** respiratoire et des tissus adjacents. Des artefacts dus au mouvement provoque par la respiration sont supprimes par la surveillance de l'etat respiratoire du patient et par l'acquisition de la position de la sonde lorsque l'etat respiratoire du patient est egal a l'etat respiratoire du patient pendant la capture d'image.

34/5/57 (Item 57 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00507965 **Image available**
INTERFACE DEVICE AND METHOD **FOR INTERFACING INSTRUMENTS TO MEDICAL** PROCEDURE **SIMULATION** SYSTEM
PROCEDE ET DISPOSITIF D'INTERFACE ENTRE DES INSTRUMENTS ET UN SYSTEME **DE SIMULATION DE** PROCEDURE **MEDICALE**
Patent Applicant/Assignee:
HT MEDICAL SYSTEMS INC,
ALEXANDER David,
BROWN J Michael,
CABAHUG Eric,
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COHEN Robert F,
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FELDMAN Ben,
FONTAYNE Diego,
MERRIL Gregory L,
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CHURCHILL Philip J,
COHEN Robert F,
CUNNINGHAM Richard L,
FELDMAN Ben,
FONTAYNE Diego,
MERRIL Gregory L,
TURCHI Mario,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9939317 A1 **19990805**
Application: WO 99US1664 19990127 (PCT/WO US9901664)
Priority Application: US 9872672 19980128; US 98105661 19981026; US 99116545 19990121
Designated States: AL AM AT AU AZ BA BB BG BR BY CA CH CN CU CZ DE DK EE ES FI GB GE GH GM HU ID IL IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT UA UG US UZ VN YU ZW GH GM KE LS MW SD SZ UG ZW AM AZ BY KG KZ MD RU TJ TM AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG
Main International Patent Class: G09B-023/28
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 17134

English Abstract
An interface device and **method** for interfacing instruments to a medical **procedure** simulation **system** serve to interface peripherals in the form of mock medical instruments to the medical **procedure** simulation **system** computer (25) to enable simulation of medical **procedures** . The interface device (20) includes a housing having a mock body region of interest to facilitate insertion of a mock instrument (22), such as an **endoscope** tube, into the interface device. The mock body region of interest may be pivotable to simulate various **patient orientations** . The instrument is engaged by a capture mechanism in order to measure

rotational and translational motion of the instrument. An actuator is disposed within the interface device to provide force feedback to the instrument.

French Abstract

La presente invention concerne un procede et un dispositif d'interface entre des instruments et un **systeme** de simulation de **procedures** medicales. Ce dispositif sert d'interface entre d'une part des peripheriques se presentant sous forme d'instruments medicaux fictifs, et d'autre part un **systeme** informatise de simulation (25) de **procedures** medicales, et ce, de facon a permettre la simulation de **procedures** medicales. Le dispositif d'interface (20) comporte un carter representant en maquette une region du corps a etudier, laquelle maquette permet l'insertion d'un instrument maquette (22) tel qu'un tube d' **endoscope** dans le dispositif d'interface. La region du corps en maquette peut etre de type pivotant pour simuler les differentes postures du patient. L'instrument est en prise sur un mecanisme de saisie informatique permettant de mesurer le mouvement de **rotation** et de translation de l'instrument. Un actionneur situe a l'interieur de l'interface fournit a l'instrument une retroaction de force.

34/5/66 (Item 66 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00451377 **Image available**
METHOD **AND APPARATUS FOR EVALUATING THE PERFORMANCE** CHARACTERISTICS **OF** ENDOSCOPES
PROCEDE ET APPAREIL D'EVALUATION DE CARACTERISTIQUES DE FONCTIONNEMENT D' ENDOSCOPES
Patent Applicant/Assignee:
HARTFORD HOSPITAL,
ROSOW Eric,
BEATRICE Finton,
ADAM Joseph,
YOUNGDAHL Curtis,
Inventor(s):
ROSOW Eric,
BEATRICE Finton,
ADAM Joseph,
YOUNGDAHL Curtis,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9841841 A1 **19980924**
Application: WO 98US5489 19980320 (PCT/WO US9805489)
Priority Application: US 97821112 19970320
Designated States: AL AM AT AU AZ BA BB BG BR BY CA CH CN CU CZ DE DK EE ES FI GB GE GH GM GW HU ID IL IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT UA UG US UZ VN YU ZW GH GM KE LS MW SD SZ UG ZW AM AZ BY KG KZ MD RU TJ TM AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN ML MR NE SN TD TG
Main International Patent Class: G01N-021/00
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 16271

English Abstract
In a **method** and apparatus for evaluating the performance **characteristics** of fiber-optic **endoscopes** , a beam of light defining a predetermined intensity pattern is transmitted through the **endoscope** from a tip end through an eyepiece end of the **endoscope** . The intensity pattern of the beam defines either a uniform intensity, or an intensity which varies sinusoidally in a predetermined **direction** across the beam. The following tests are performed in order to evaluate both the optical fibers and the lens **system** of the **endoscope** , and the intensity pattern is selected in accordance with the requirements of the respective test: (i) a light loss test, (ii) a reflective symmetry test, (iii) a lighted fibers test, (iv) a geometric distortion test, and (v) a MTF test. A video **system** (22) generates signals indicative of the optical intensity of the beam after transmission through the **endoscope** at each of the plurality of predetermined locations within the beam. The video signals are in turn evaluated in accordance with the selected tests in order to provide graphical and numerical indicia of the optical performance **characteristics** of the **endoscope** .

French Abstract
L'invention concerne un procede et un appareil d'evaluation de caracteristiques de fonctionnement d' **endoscopes** a fibres optiques, un faisceau lumineux definissant un diagramme d'intensite predetermine etant

transmis a travers l' **endoscope** , d'une extremite de pointe a une extremite oculaire de l' **endoscope** . Le diagramme d'intensite du faisceau definit soit une intensite uniforme, soit une intensite qui varie de maniere sinusoidale dans une **direction** predeterminee a travers le faisceau. On procede aux essais suivants pour evaluer les fibres optiques et le **systeme** de lentilles de l' **endoscope** , et on selectionne le diagramme d'intensite conformement aux exigences de l'essai concerne: (i) un essai de perte de flux lumineux; (ii) un essai de symetrie de reflexion; (iii) un essai d'illumination de fibres; (iv) un essai de distorsion geometrique; et (v) un essai de fonction de transfert de modulation (MTF). Un **systeme** video (22) genere des signaux indiquant l'intensite optique du faisceau apres transmission a travers l' **endoscope** a chaque emplacement parmi plusieurs emplacements predetermines a l'interieur du faisceau. Les signaux video sont evalues a tour de role conformement aux essais selectionnes afin de definir des indicateurs graphiques et numeriques des caracteristiques de fonctionnement optiques de l' **endoscope** .

34/5/67 (Item 67 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00448443 **Image available**
INSTRUMENT FOR OPTICALLY SCANNING OF LIVING TISSUE
INSTRUMENT D'ANALYSE A BALAYAGE OPTIQUE DE TISSU VIVANT
Patent Applicant/Assignee:
MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
Inventor(s):
BOPPART Stephen A,
TEARNEY Gary J,
BOUMA Brett E,
BREZINSKI Mark E,
FUJIMOTO James G,
SWANSON Eric A,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9838907 A1 **19980911**
Application: WO 98US4364 19980306 (PCT/WO US9804364)
Priority Application: US 9738047 19970306; US 9754163 19970729
Designated States: JP AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE
Main International Patent Class: **A61B-005/00**
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 24858

English Abstract
An imaging **system** includes forward directed optical coherence tomography (OCT), and non-retroreflected forward scanning OCT, and also interferometric imaging and ranging techniques and fluorescent, Raman, two-photon, and diffuse wave imaging can be used. The forward scanning mechanisms include a cam (70) attached to a motor (61), pneumatic devices (96), a pivoting device (90, 94), piezoelectric transducers (74), electrostatic driven slides (108) for substantially transverse scanning; counter-rotating prisms (144), and offset lenses (62) are used for arbitrary scanning. The imaging **system** of the invention is applied to hand held probes including probes integrated with surgical probes, scalpels, scissors, forceps and **biopsy** instruments. Hand held probes include forward scanning lasers. The imaging **system** is also applicable to laparoscopes and **endoscopes** for diagnostic and therapeutic intervention in body orifices, canals, tubes, ducts, vessels and cavities of the body.

French Abstract
L'invention concerne un **systeme** d'imagerie comprenant une tomographie a coherence optique (OCT) dirigee vers l'avant, et une OCT par balayage vers l'avant non retroreflechissant. On peut egalement utiliser des techniques de telemetrie et d'image interferometriques et une image fluorescente, a effet Raman, a deux photons, et a ondes diffuses. Les mecanismes de balayage vers l'avant comprennent une came fixee a un moteur, des dispositifs pneumatiques, un dispositif pivotant, des transducteurs piezoelectriques, et des lames electrostatiques permettant un balayage essentiellement transversal; des prismes contrarotatifs et des lentilles decalees permettent un balayage arbitraire. Le **systeme** d'image de l'invention s'applique a des sondes manuelles y compris des sondes integrees a des sondes chirurgicales, des scalpels, des ciseaux, des pinces et des instruments de **biopsie** . Les sondes manuelles comprennent des lasers a balayage vers l'avant. Le **systeme** d'image

s'applique egalement a des laparoscopes et des **endoscopes** destines a des interventions diagnostiques et therapeutiques dans des orifices du corps, des canaux, des tubes, des conduits, des vaisseaux, et des cavites du corps.

34/5/68 **(Item 68 from file: 349)**
DIALOG(R)File 349:PCT FULLTEXT

00446220
IMAGE-GUIDED THORACIC THERAPY AND APPARATUS THEREFOR
THERAPIE DU THORAX GUIDEE PAR IMAGE ET APPAREIL PREVU A CET EFFET
Patent Applicant/Assignee:
BIOSENSE INC,
Inventor(s):
ACKER David E,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9836684 A1 **19980827**
Application: WO 98US3660 19980225 (PCT/WO US9803660)
Priority Application: US 9738497 19970225
Designated States: AL AM AT AU AZ BA BB BG BR BY CA CH CN CU CZ DE DK EE ES FI GB GE GH GM GW HU ID IL IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT UA UG UZ VN YU ZW GH GM KE LS MW SD SZ UG ZW AM AZ BY KG KZ MD RU TJ TM AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN ML MR NE SN TD TG
Main International Patent Class: **A61B-005/00**
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 8008

English Abstract
A probe such as an **endoscope** equipped with a **biopsy** needle is guided to a target in or adjacent to the respiratory **system** . The position of the probe is monitored. A representation of the probe is superimposed on a previously acquired image of the respiratory **system** and adjacent tissues. Artifacts caused by motion due to respiration are suppressed by monitoring the respiratory state of the patient, and acquiring the probe position when the respiratory state of the patient is equal to the respiratory state of the **patient** during **image** capture.

French Abstract
L'invention concerne une sonde, tel un **endoscope** , equipee d'une aiguille a ponction- **biopsie** , qui est guidee vers une cible situee dans le **systeme** respiratoire ou de facon adjacente a celui-ci. La position de la sonde est surveillee. Une representation de la sonde est superposee a une image du **systeme** respiratoire et des tissus adjacents acquise precedemment. Des artefacts provoques par des mouvements dus a la respiration sont supprimes par une surveillance de l'etat respiratoire du patient, et un enregistrement de la position de la sonde au moment ou l'etat respiratoire du patient est egal a l'etat respiratoire du patient au cours de l'acquisition de l'image.

34/5/70 (Item 70 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00416540 **Image available**
APPARATUS AND METHOD FOR MAKING ACCURATE THREE-DIMENSIONAL SIZE MEASUREMENTS OF INACCESSIBLE OBJECTS
APPAREIL ET PROCEDE DE MESURE DE TAILLE EN TROIS DIMENSIONS D'OBJETS INACCESSIBLES

Patent Applicant/Assignee:
SCHAACK David F,
Inventor(s):
SCHAACK David F,

Patent and Priority Information (Country, Number, Date):
Patent: WO 9807001 A1 19980219
Application: WO 97US15206 19970808 (PCT/WO US9715206)
Priority Application: US 96689993 19960816; US 97871289 19970609
Designated States: AU CA CN DE GB JP MX AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE
Main International Patent Class: G01B-011/02
International Patent Class: **A61B-05:107** ; G02B-23:24
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 41223

English Abstract
Spatial locations of individual points on an inaccessible object are determined by measuring two images acquired with one or more cameras which can be moved to a plurality of positions and orientations which are accurately determined relative to the instrument. Once points are located, distances are easily calculated. This new system offers accurate measurements with any convenient geometry, and with existing endoscopic apparatus. It also provides for the measurement of distances which cannot be contained within any single camera view. Systematic errors are minimized by use of a complete and robust set of calibration procedures. A standard measurement procedure automatically adjusts the measurement geometry to reduce random errors. A least squares calculation uses all of the image location and calibration data to derive the true three-dimensional positions of the selected object points. This calculation is taught explicitly for any camera geometry and motion.

French Abstract
On determine les emplacements dans l'espace des points individuels d'un objet inaccessible en mesurant deux images acquises au moyen d'une ou plusieurs cameras qui peuvent etre deplacees selon une serie de positions et d'orientations qui sont exactement determinees par rapport a l'instrument. Une fois que les points ont ete situes, on peut aisement calculer les distances. Ce nouveau systeme offre des mesures precises avec toute geometrie commode, et avec les appareils endoscopiques actuels. Il decrit aussi la mesure des distances que ne peut contenir une vue unique de camera. Les erreurs systematiques sont minimisees par l'emploi d'un ensemble robuste et complet de procedures d'etalonnage. Une procedure ordinaire de mesure ajuste automatiquement la geometrie de mesure de facon a reduire les erreurs aleatoires. Des calculs a angles droits utilisent tout l'emplacement d'image et des donnees d'etalonnage pour deduire les vraies positions tridimensionnelles des points choisis d'objet. Ce calcul est enseigne explicitement pour toute geometrie et tout mouvement de camera.

34/5/71 (Item 71 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00391439 **Image available**
METHOD **AND APPARATUS FOR PERFORMING OPTICAL MEASUREMENTS USING A FIBER OPTIC IMAGING GUIDEWIRE, CATHETER OR** ENDOSCOPE
PROCEDE ET APPAREIL PERMETTANT D'EFFECTUER DES MESURES OPTIQUES A L'AIDE D'UN ENDOSCOPE **, UN CATHETER OU UN FIL DE GUIDAGE D'IMAGERIE A FIBRE OPTIQUE**

Patent Applicant/Assignee:
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Inventor(s):
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BOUMA Brett E,
BREZINSKI Mark,
SWANSON Eric A,
Fujimoto James G,

Patent and Priority Information (Country, Number, Date):
Patent: WO 9732182 A1 **19970904**
Application: WO 97US3033 19970227 (PCT/WO US9703033)
Priority Application: US 96607787 19960227
Designated States: AL AM AT AU AZ BA BB BG BR BY CA CH CN CU CZ DE DK EE ES FI GB GE GH HU IL IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK TJ TM TR TT UA UG UZ VN YU GH KE LS MW SD SZ UG AM AZ BY KG KZ MD RU TJ TM AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN ML MR NE SN TD TG
Main International Patent Class: G01B-011/12
International Patent Class: G01B-09:02; G01B-11:02
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 12843

English Abstract
An imaging **system** for performing optical coherence tomography includes an optical radiation source; a reference optical reflector; a first optical path leading to the reference optical reflector; and a second optical path coupled to an **endoscopic** unit. The **endoscopic** unit preferably includes an elongated housing defining a bore; a rotatable single mode optical fiber having a proximal end and a distal end positioned within and extending the **length** of the bore of the elongated housing; and an optical **system** coupled to the distal end of the rotatable single mode optical fiber, positioned to transmit the optical radiation from the single mode optical fiber to the structure and to transmit reflected optical radiation from the structure to the single mode optical fiber. The **system** further includes a beam divider dividing the optical radiation from the optical radiation source along the first optical path to the reflector and along the second optical path; and a detector positioned to receive reflected optical radiation from the reflector transmitted along the first optical path and reflected optical radiation transmitted from the structure along the second optical path. The detector generates a signal in response to the reflected optical radiation from the reference reflector and the reflected optical radiation from the structure, and a processor generating an image of the structure in response to the signal from the detector. The **system** provides both **rotational** and longitudinal scanning of an image.

French Abstract

Un **systeme** d'imagerie permettant d'effectuer une tomographie de coherence optique comprend une source de rayonnement optique, un reflecteur optique de reference, un premier chemin optique menant au reflecteur optique de reference, et un second chemin optique couple a un **endoscope** . L' **endoscope** comprend de preference un boitier allonge definissant un alesage, une fibre optique rotative monomode ayant une extremite proximale et une extremite distale positionnee et s'etendant sur la longueur de l'alesage du boitier allonge, et un **systeme** optique couple a l'extremite distale de la fibre optique monomode rotative, et positionne afin de transmettre le rayonnement optique de la fibre optique monomode a la structure et transmettre le rayonnement optique reflechi de la structure a la fibre optique monomode. Le **systeme** comprend en outre un diviseur de faisceau qui divise le rayonnement optique provenant de la source de rayonnement optique le long du premier chemin optique et allant au reflecteur et le long du second chemin optique; et un detecteur positionne afin de recevoir un rayonnement optique reflechi par le reflecteur et transmis le long du premier chemin optique et un rayonnement optique reflechi transmis par la structure le long du second chemin optique. Le detecteur genere un signal en reponse au rayonnement optique reflechi provenant du reflecteur de reference et le rayonnement optique reflechi provenant de la structure; un **processeur** genere une image de la structure en reponse au signal provenant du detecteur. Le **systeme** fournit un balayage a la fois rotatif et longitudinal d'une image.

34/5/72 (Item 72 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00360324 **Image available**
ARTICULATED ARM FOR MEDICAL PROCEDURES
BRAS ARTICULE POUR DES PROCEDURES **MEDICALES**
Patent Applicant/Assignee:
  NG Wan Sing,
Inventor(s):
  NG Wan Sing,
Patent and Priority Information (Country, Number, Date):
  Patent: WO 9700649 A1 **19970109**
  Application: WO 95SG9 19950620 (PCT/WO SG9500009)
  Priority Application: WO 95SG9 19950620
Designated States: AM AT AU BB BG BR BY CA CH CN CZ DE DK EE ES FI GB GE HU IS JP KE KG KP KR KZ LK LR LT LU LV MD MG MN MW MX NO NZ PL PT RO RU SD SE SG SI SK TJ TM TT UA UG US UZ VN KE MW SD SZ UG AT BE CH DE DK ES FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN ML MR NE SN TD TG
Main International Patent Class: **A61B-019/00**
Publication Language: English
Fulltext Availability:
  Detailed Description
  Claims
Fulltext Word Count: 9866

English Abstract
An articulated arm is disclosed which can be used to firmly support and position a variety of medical tools, including surgical or diagnostic instruments flexibly in space. Though some of its sub-assemblies may be computer controlled, thus autonomous in accordance to some pre-programmed sequence, manual control is also possible. When its sub-assemblies are suitably controlled using computer software, and with a suitable cutting instrument, the arm is capable of generating a barrel shape cavity or, for that matter, any desired shape of cavity (or treatment volume) that is within the work envelope of the arm. The ideal position of the focal point is dynamically variable as required, either with respect to the tool or the absolute frame of reference, during an intervention. A suitable type of intervention is minimally invasive surgery (MIS). Apart from cutting (or resection), the articulated arm, by virtue of its robotic nature, can also be used to perform such tasks as **biopsies** and radiation seed implantation, where positional accuracy and repeatability are highly desirable. The articulated arm is a universal computer assisted holder for a wide range of medical tools, in particular **endoscopes** for treatment of urological disorders.

French Abstract
L'invention concerne un bras articule qui peut etre utilise pour tenir fermement et positionner, d'une maniere flexible dans l'espace, une variete d'instruments medicaux, en particulier des instruments chirurgicaux ou des instruments pour diagnostics. Bien que certains de ses elements puissent etre commandes par ordinateur, donc travailler d'une maniere autonome en fonction d' **instructions** programmees, une commande manuelle est egalement possible. Quand ces elements sont commandes par un ordinateur en utilisant des logiciels appropries et qu'ils portent un instrument coupant approprie, le bras peut produire une cavite (ou volume de traitement) de forme cylindrique ou de n'importe quelle autre forme a l'interieur de l'enveloppe de travail du bras. La position ideale du point focal peut etre modifiee dynamiquement et a volonte durant une intervention, soit par rapport a l'outil, soit par

rapport a un **systeme** de reference absolu. Le bras permet d'effectuer des operations chirurgicales en minimisant leur caractere invasif. A part les operations proprement chirurgicales (par exemple resection), le bras articule, qui est un robot, peut egalement etre utilise pour des **biopsies** et des implantations de sources radioactives, ou la precision et la reproductibilite sont essentielles. Le bras articule assiste par ordinateur peut servir de support a toute une gamme d'instruments chirurgicaux, en particulier a des **endoscopes** destines a des interventions en urologie.

34/5/73 (Item 73 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00348372 **Image available**
VIRTUAL SURGERY SYSTEM
SYSTEME **DE CHIRURGIE VIRTUELLE**
Patent Applicant/Assignee:
GILLIO Robert G,
Inventor(s):
GILLIO Robert G,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9630885 A1 **19961003**
Application: WO 96US4401 19960328 (PCT/WO US9604401)
Priority Application: US 95412805 19950329
Designated States: AL AM AU AZ BB BG BR BY CA CN CZ EE FI GE HU IS JP KE KG KP KR KZ LK LR LT LV MD MG MK MN MW MX NO NZ PL RO RU SD SG SI SK TJ TM TT UA UG UZ VN KE LS MW SD SZ UG AM AZ BY KG KZ MD RU TJ TM AT BE CH DE DK ES FI FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN ML MR NE SN TD TG
Main International Patent Class: G09B-023/28
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 13051

English Abstract
A virtual surgery **system** or virtual testing **system** provides a simulation or test based on image data. A simulator combined with a real exam requires simulation tasks by a test taker. Additionally, a surgical **procedure** may be simulated using **image** data of a **patient** in devices simulating the physical instruments a surgeon uses in performing the actual **procedure** (106), for example. The user input device (106), such as a mouse, three dimensional mouse, joystick, seven dimensional joystick, full size simulator, etc., can be used in a virtual simulation to move through the image data while the user looks at the data and interaction of the input device with the image data on a display screen (130). Force feedback can be provided based on physical constraint models (of the anatomy, for example), or based on edge and collision detection between the virtual scope or virtual tool used by the operator and walls or edges of the image data in the **image** space. The **virtual** simulator may be used as a teaching, training, testing, demonstration, or remote telesurgery device, for example.

French Abstract
Systeme de chirurgie virtuelle ou de test virtuel produisant une simulation ou un test se basant sur des donnees d'images. Un simulateur combine a un examen reel necessitent des taches de simulation de la part de la personne effectuant le test. De plus, une operation chirurgicale peut etre simulee au moyen des donnees d' **images** d'un **patient** dans des dispositifs simulant les instruments physiques utilises par un chirurgien pour une operation reelle (106). Le dispositif (106) d'entree de l'utilisateur, tel qu'une souris, une souris tridimensionnelle, une manette, une manette a sept dimensions, un simulateur en grandeur nature entre autres, peut s'utiliser en simulation virtuelle afin de faire defiler les donnees d'images tandis que l'utilisateur visualise les donnees et l'interaction du dispositif d'entree avec les donnees d'images sur un ecran (130). Une reaction de force peuvent etre obtenue en fonction de modeles de contraintes physiques (par exemple, de l'anatomie)

ou en fonction de la detection de bord et de collision entre la portee virtuelle ou l'outil virtuel utilise par l'operateur et les parois ou les bords des donnees d'images dans l'espace de l'image. Le simulateur virtuel peut s'utiliser en tant que dispositif d'enseignement, de formation, de test, de demonstration ou de chirurgie a **distance** , par exemple.

34/5/75 (Item 75 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00333878 **Image available**
MEDICAL PROCEDURE **SIMULATOR**
SIMULATEUR D'ACTES MEDICAUX
Patent Applicant/Assignee:
STANEFF John E Jr,
MOORE Robert S,
HARTHAN Lewis John III,
LIVEZEY Darrell L,
JONES Robert F,
LUDKE David L,
CATALLO Leo R,
Inventor(s):
STANEFF John E Jr,
MOORE Robert S,
HARTHAN Lewis John III,
LIVEZEY Darrell L,
JONES Robert F,
LUDKE David L,
CATALLO Leo R,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9616389 A1 **19960530**
Application: WO 95US14368 19951117 (PCT/WO US9514368)
Priority Application: US 94341686 19941117
Designated States: AL AM AT AU BB BG BR BY CA CH CN CZ DE DK EE ES FI GB GE HU IS JP KE KG KP KR KZ LK LR LT LU LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK TJ TM TT UA US UZ VN KE LS MW SD SZ UG AT BE CH DE DK ES FR GB GR IE IT LU MC NL PT SE BF BJ CF CG CI CM GA GN ML MR NE SN TD TG
Main International Patent Class: G09B-023/28
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 11832

English Abstract
An interactive medical **procedure** simulation **system** having a mannequin (21) with life-like qualities of appearance, feel and touch. The mannequin is equipped with one or more trocars (23, 24) into which there are selectively **inserted** simulations of conventional medical **procedure** tools (25, 26) for diagnosis and treatment. Provision is made for creating and displaying (30) seamless representations or realistic real-life internal landscapes which are changeable to track changes in positions of simulated **endoscopes** and medical tools. Realism is enhanced through the use of pneumatically operated force feedback so as to enhance realistic feel for simulated **procedures** including tugging, tearing, cutting, clipping, stapling, pulling, pushing, grasping and probing.

French Abstract
Systeme interactif de simulation d'actes medicaux faisant appel a un mannequin (21) ayant un aspect et une consistance naturels. Le mannequin comporte un ou plusieurs trocarts (23, 24) dans lesquels on a introduit selectivement des simulations d'outils de diagnostic et de traitement (25, 26) permettant de proceder a des actes medicaux traditionnels. Il est possible de creer et de visualiser (30) des representations realistes

et homogenes d'environnements internes reels, modifiables pour suivre les changements de position des **endoscopes** et des instruments medicaux simules. Le realisme est ameliore par l'emploi d'un retour d'effort a action pneumatique qui donne une sensation realiste des gestes simules: dechirer, couper, tailler, agrafer, tirer, pousser, saisir et sonder.

34/5/76 (Item 76 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00310720
SELF-CENTERING ENDOSCOPE SYSTEM
SYSTEME **D'** ENDOSCOPE **A CENTRAGE AUTOMATIQUE**
Patent Applicant/Assignee:
FELDSTEIN David A,
ALTMAN Kenneth A,
Inventor(s):
FELDSTEIN David A,
ALTMAN Kenneth A,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9528872 A1 **19951102**
Application: WO 94US4450 19940422 (PCT/WO US9404450)
Priority Application: WO 94US4450 19940422
Designated States: CA JP AT BE CH DE DK ES FR GB GR IE IT LU MC NL PT SE
Main International Patent Class: **A61B-001/06**
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 5504
English Abstract
A self- **guiding** , self-centering **endoscope** **system** provides for the advance of a head (10) of an **endoscope** (12) through the lumen of an internal organ with minimal discomfort to the patient in which use of anesthesia is substantially eliminated. The **guiding** **system** is implemented through an algorithm controlled computer (36) **processing** about 136 coordinate sectors of an electronic mask applied to a video output of the **endoscope** camera (13). This output is digitized by a video **processing** unit (38) and fed into a computer module (40) in which the algorithm compares derived gray scale values of the sectors with a preset gray scale **parameter** to differentiate between levels of varying reflectivity within and upon the walls of the lumen to thereby ascertain the best path for the head (10) of the **endoscope** (12). Through use of X-axis and Y-axis servo amplifiers (16) and motors (18, 20, 22), a real time correction of the position of the **endoscope** head (10) is obtained relative to the center of the lumen.

French Abstract
La presente invention concerne une **systeme** d' **endoscope** a guidage et centrage automatiques, concu pour faire avancer la tete (10) de l' **endoscope** (12) dans le lumen d'un organe interne, avec un minimum d'inconfort pour le patient, l'usage d'un anesthesiant etant de ce fait quasiment superflu. Le **systeme** de guidage est realise par traitement informatique (36) a commande algorithmique d'environ 136 secteurs de coordonnees d'un masque electronique applique aux donnees de sortie video d'une camera **endoscopique** (13). Ces donnees de sortie sont numerisees par une unite de traitement video (38) et introduites dans un module d'ordinateur (40) dans lequel l'algorithme compare les valeurs de l'echelle de gris des secteurs avec un parametre preetabli de cette echelle de gris, afin de differencier entre des niveaux de pouvoir de reflexion variables dans le lumen et sur les parois de celui-ci et de determiner ainsi le meilleur trajet pour la tete (10) de l' **endoscope** (12). Par l'utilisation de servo-amplificateurs (16) et de moteurs (18, 20, 22) d'axe X et d'axe Y, on obtient une correction en temps reel de la position de la tete (10) de l' **endoscope** par rapport au centre du lumen.

34/5/78 (Item 78 from file: 349)
DIALOG(R)File 349:PCT FULLTEXT

00267351 **Image available**
MEDICAL VIDEO ENDOSCOPE SYSTEM
SYSTEME **D'** ENDOSCOPE **VIDEO MEDICAL**
Patent Applicant/Assignee:
AMERICAN SURGICAL TECHNOLOGIES CORPORATION,
Inventor(s):
WEAVER Charles,
CHALEKI Christopher R,
Patent and Priority Information (Country, Number, Date):
Patent: WO 9415521 A1 **19940721**
Application: WO 94US116 19940104 (PCT/WO US9400116)
Priority Application: US 93664 19930105; US 93544 19930614
Designated States: CA JP AT BE CH DE DK ES FR GB GR IE IT LU MC NL PT SE
Main International Patent Class: **A61B-001/04**
International Patent Class: **A61B-01:00**
Publication Language: English
Fulltext Availability:
Detailed Description
Claims
Fulltext Word Count: 13519

English Abstract
A medical video **endoscope system** (22) for allowing high-resolution three-dimensional images to be viewed has a stereoscopic **endoscope** (26) for converting optical images of an object (24) to left and right video image signals (58, 60). An electronic processor module (30) controls the stereoscopic **endoscope** (26) and **processes** the left and right video image signals (58, 60) into time-multiplexed signals (62, 64) representative of high-resolution three-dimensional images having stereoscopic **depth** . The time-multiplexed signals (62, 64) are provided to a monitor (32) which displays high-resolution video images (54, 56) based on the signals. A viewing device (34) is provided which allows a viewer to see high-resolution three-dimensional video images having stereoscopic **depth** on the monitor (32).

French Abstract
Systeme (22) d' **endoscope** video medical permettant de visualiser des images tridimensionnelles a haute resolution comprenant un **endoscope** (26) stereoscopique qui transforme les images optiques d'un objet (24) en signaux (58, 60) d'image video gauche et droit. Un module (30) de traitement electronique commande l' **endoscope** (26) stereoscopique et transforme les signaux (58, 60) d'image video gauche et droit en signaux (62, 64) multiplexes dans le temps representant des images tridimensionnelles a haute resolution ayant une profondeur stereoscopique. Les signaux (62, 64) multiplexes dans le temps sont transmis a un ecran (32) de visualisation qui affiche les images (54, 56) video a haute resolution a partir desdits signaux. Un dispositif (34) de visualisation permet a un utilisateur de voir a l'ecran (32) les images tridimensionnelles a haute resolution avec une profondeur stereoscopique.

```
Set      Items   Description
S1    17561698   METHOD?
S2    26080448   SYSTEM?
S3     2921662   PROCEDURE?
S4     9561568   PROCESS?
S5      485207   VIDEOSCOP? OR BRONCOSCOP? OR BRONCHOSCOP? OR BRONCHISCOP? -
              OR ENDOSCOP? OR FLEXIBLE()(TOOL? OR INSTRUMENT? OR CYLINDER?)
S6       12863   DC=(E7.230.220? OR E7.858.240?)
S7     1665450   INSTRUCTION? OR DIRECTION? OR NAVIGATION?
S8      536988   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
              CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
              PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(MODEL? OR PLA-
              N? OR PATH? OR GEOMETR? OR MAP OR MAPPING OR MAPS)
S9      213690   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
              CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
              PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(IMAGE? ? OR I-
              MAGING OR ORIENTATION? OR CONFIGURATION? OR TRAJECT?)
S10     188445   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
              CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
              PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(CT OR CAT OR -
              TOMOGRAPH? OR MRI OR ULTRASO? OR MAGNETIC?()RESONAN?)
S11      15055   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
              CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
              PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(2()D OR 2DIME-
              NSION? OR 2()DIMENSION? OR TWODIMENS? OR TWO()DIMENSION?)
S12      19403   (PREDETERMIN? OR PREOPERAT? OR VIRTUAL? OR PATIENT? OR SPE-
              CIFIC? OR PHANTOM? OR SPATIAL? OR CUSTOMI? OR INDIVIDUALI? OR
              PERSONALI? OR CUSTOM()MADE OR TAILOR()MADE)(3N)(3()D OR 3DIME-
              NS? OR 3()DIMENS? OR THREEDIMEN? OR THREE()DIMEN?)
S13     851034   TBNA OR TRANSBRON?()NEEDLE?()ASPIRAT? OR BIOPS?
S14    8762724   CHARACTERISTIC? OR PARAMETER? OR ROTATION?
S15    4492094   DIAMETER? OR LENGTH? OR DISTANCE? OR DEPTH?
S16    3029639   BEND? OR DEFLECT? OR CURV? OR ANGLE? ?
S17     131098   (ANATOM? OR BODY OR BODILY)(2N)(LANDMARK? OR SITE? OR TARG-
              ET? OR STRUCTURE? OR PART?) OR CARINA?
S18    5368488   LESION? OR TUMOR? OR TUMOUR? OR TRACHEOBRONC?
S19    1166588   GUIDE? ? OR GUIDING OR MANIPULAT?
S20    6232043   HANDLE? ? OR HANDLING OR INSERT? OR OPERAT?
S21     285140   S1:S4 AND S5:S6
S22       3209   S21 AND S7:S12 AND S14:S18 AND S19:S20
S23        719   S22 AND S13
S24       3209   S22:S23
S25        855   S24 AND S1:S4(5N)S5:S6
S26        679   S24 AND S1:S4(5N)S19:S20
S27        225   S25:S26 AND S7:S12(5N)S14:S18
S28        291   S25 AND S26
S29         45   S27 AND S28
S30         23   RD (unique items)
S31         19   S30 AND PY<2002
? show files
File   2:INSPEC 1969-2003/Dec W2
         (c) 2003 Institution of Electrical Engineers
File   5:Biosis Previews(R) 1969-2003/Dec W3
         (c) 2003 BIOSIS
File   6:NTIS 1964-2003/Dec W4
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File  34:SciSearch(R) Cited Ref Sci 1990-2003/Dec W4
         (c) 2003 Inst for Sci Info
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File 144:Pascal 1973-2003/Dec W2
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         (c) 2003 FIZ TECHNIK
File  71:ELSEVIER BIOBASE 1994-2003/Dec W4
         (c) 2003  Elsevier Science B.V.
```

31/5,K/1 (Item 1 from file: 2)
DIALOG(R)File 2:INSPEC

5445911 INSPEC Abstract Number: B9701-6140C-565, C9701-1250-331
Title: Vision based navigation system **for an** endoscope
Author(s): Khan, G.N.; Gillies, D.F.
Author Affiliation: Coll. of Electr. & Mech. Eng., Nat. Univ. of Sci. & Technol., Rawalpindi, Pakistan
Journal: Image and Vision Computing vol.14, no.10 p.763-72
Publisher: Elsevier,
Publication Date: Dec. 1996 Country of Publication: Netherlands
CODEN: IVCODK ISSN: 0262-8856
SICI: 0262-8856(199612)14:10L.763:VBNS;1-G
Material Identity Number: F298-96003
U.S. Copyright Clearance Center Code: 0262-8856/96/$15.00
Document Number: S0262-8856(96)01085-2
Language: English Document Type: Journal Paper (JP)
Treatment: Practical (P); Theoretical (T)
Abstract: A vision based **navigation system** to **guide** an **endoscope** inside a human colon has been designed and tested. It uses low level vision techniques to extract two types of **navigational** landmarks, dark regions and **curved** contours. Dark regions correspond to the distant inner space of the colon, called the lumen. The **curved** contours represent occlusions due to the inner colon muscles. A hierarchical search space and environment representation, called the QL-tree, was developed to integrate the visual features and implement the **navigation system** . It uses multiple quadtrees which are linked at all hierarchical levels. A multiprocessor **system** was employed to achieve real-time performance. The **endoscope navigation system** has been used successfully in artificial colon models. (32 Refs)
Subfile: B C
Descriptors: computer vision; **navigation** ; quadtrees
Identifiers: vision based **navigation system** ; **endoscope** ; human colon ; low level vision techniques; **navigational** landmarks; dark regions; **curved** contours; occlusions; inner colon muscles; QL-tree; visual features ; multiple quadtrees; multiprocessor **system** ; real-time performance; artificial colon models
Class Codes: B6140C (Optical information, image and video signal processing); B0250 (Combinatorial mathematics); C1250 (Pattern recognition); C5260B (Computer vision and image processing techniques); C6120 (File organisation); C1160 (Combinatorial mathematics)

Title: Vision based navigation system **for an** endoscope
Abstract: A vision based **navigation system** to **guide** an **endoscope** inside a human colon has been designed and tested. It uses low level vision techniques to extract two types of **navigational** landmarks, dark regions and **curved** contours. Dark regions correspond to the distant inner space of the colon, called the lumen. The **curved** contours represent occlusions due to the inner colon muscles. A hierarchical search space and environment representation, called the QL-tree, was developed to integrate the visual features and implement the **navigation system** . It uses multiple quadtrees which are linked at all hierarchical levels. A multiprocessor **system** was employed to achieve real-time performance. The **endoscope navigation system** has been used successfully in artificial colon models.
...Descriptors: **navigation** ;
Identifiers: vision based **navigation system** ; ...

... **endoscope** ; ...

... **navigational** landmarks...

... **curved** contours...

...multiprocessor **system** ;
1996

31/5,K/2 (Item 1 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

0012960859 BIOSIS NO.: 200100132698
Preoperative staging of periampullar cancer with US, CT, EUS and CA 19-9
AUTHOR: Tomazic Ales (Reprint); Pegan Vladislav
AUTHOR ADDRESS: Dept. of Abdominal Surgery, University Medical Center, Zaloska cesta 7, 1525, Ljubljana, Slovenia**Slovenia
JOURNAL: Hepato-Gastroenterology 47 (34): p1135-1137 July-August, 2000
2000
MEDIUM: print
ISSN: 0172-6390
DOCUMENT TYPE: Article
RECORD TYPE: Abstract
LANGUAGE: English

ABSTRACT: Background/Aims: Several diagnostic **methods** are available for preoperative staging of periampullary cancers. It happens that on the basis of preoperative findings the patient is prepared for radical surgery, but during the **operation** the **lesion** turns out to be unresectable. **Methodology** : We studied 43 patients **operated** on for periampullary cancer. Preoperatively, all **patients** were evaluated by **ultrasonography** , computed tomography, **endoscopic** ultrasonography and the level of carbohydrate antigen 19-9 was assessed. Statistical **parameters** were calculated and compared. Results: **Endoscopic ultrasonography** has **specificity** of 70.8% and positive predictive value regarding **tumor** resectability 55.8%. Computed **tomography** has a **specificity** of 45.8% and carbohydrate antigen 19-9 of 66.7%. Positive predictive value for computed tomography and carbohydrate antigen 19-9 is 40.6% and 52.6%, respectively. Ultrasonography is the least accurate **method** with specificity of 12.5% and positive predictive value 29.7%. A combined use of different diagnostic **methods** has higher positive predictive value, highest (65.1%) being found for the combination of **endoscopic** ultrasonography and carbohydrate antigen 19-9. Statistical tests showed statistically significant differences between diagnostic **methods** . Conclusions: Among the diagnostic **methods** studied, **endoscopic** ultrasonography showed the highest accuracy in predicting **tumor** resectability. The use of either **endoscopic** ultrasonography and carbohydrate antigen 19-9 or computed tomography and carbohydrate antigen 19-9 is accurate enough for assessing **tumor** resectability.

DESCRIPTORS:
MAJOR CONCEPTS: Gastroenterology--Human Medicine, Medical Sciences; Oncology--Human Medicine, Medical Sciences; Radiology--Medical Sciences
BIOSYSTEMATIC NAMES: Hominidae--Primates, Mammalia, Vertebrata, Chordata, Animalia
ORGANISMS: human (Hominidae)--patient
COMMON TAXONOMIC TERMS: Animals; Chordates; Humans; Mammals; Primates; Vertebrates

DISEASES: periampullar cancer--endocrine disease/pancreas, neoplastic disease, preoperative staging
CHEMICALS & BIOCHEMICALS: CA 19-9 {carbohydrate antigen 19-9}
METHODS & EQUIPMENT: computed tomography--staging **method** ; **endoscopic** ultrasonography--staging **method** ; ultrasonography--staging **method**

CONCEPT CODES:
14006 Digestive system - Pathology
06504 Radiation biology - Radiation and isotope techniques
17008 Endocrine - Pancreas
24004 Neoplasms - Pathology, clinical aspects and systemic effects

BIOSYSTEMATIC CODES:
86215 Hominidae

2000

ABSTRACT: Background/Aims: Several diagnostic **methods** are available for preoperative staging of periampullary cancers. It happens that on the basis of preoperative findings the patient is prepared for radical surgery, but during the **operation** the **lesion** turns out to be unresectable. **Methodology** : We studied 43 patients **operated** on for periampullary cancer. Preoperatively, all **patients** were evaluated by **ultrasonography** , computed tomography, **endoscopic** ultrasonography and the level of carbohydrate antigen 19-9 was assessed. Statistical **parameters** were calculated and compared. Results: **Endoscopic ultrasonography** has **specificity** of 70.8% and positive predictive value regarding **tumor** resectability 55.8%. Computed **tomography** has a **specificity** of 45.8% and carbohydrate antigen 19-9 of 66.7%. Positive predictive value for...

...antigen 19-9 is 40.6% and 52.6%, respectively. Ultrasonography is the least accurate **method** with specificity of 12.5% and positive predictive value 29.7%. A combined use of different diagnostic **methods** has higher positive predictive value, highest (65.1%) being found for the combination of **endoscopic** ultrasonography and carbohydrate antigen 19-9. Statistical tests showed statistically significant differences between diagnostic **methods** . Conclusions: Among the diagnostic **methods** studied, **endoscopic** ultrasonography showed the highest accuracy in predicting **tumor** resectability. The use of either **endoscopic** ultrasonography and carbohydrate antigen 19-9 or computed tomography and carbohydrate antigen 19-9 is accurate enough for assessing **tumor** resectability.

DESCRIPTORS:
...METHODS & EQUIPMENT: staging **method** ; ...

... **endoscopic** ultrasonography...

...staging **method** ; ...

...staging **method**

31/5,K/3 (Item 2 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

0012599353 BIOSIS NO.: 200000317666
Pathophysiology of long-standing overt ventriculomegaly in adults
AUTHOR: Oi Shizuo (Reprint); Shimoda Masami; Shibata Masayoshi; Honda Yumie ; Togo Kouji; Shinoda Masaki; Tsugane Ryuichi; Sato Osamu
AUTHOR ADDRESS: Department of Neurosurgery, School of Medicine, Tokai

University, Bohseidai, Isehara-City, Kanagawa, 259-1193, Japan**Japan
JOURNAL: Journal of Neurosurgery 92 (6): p933-940 June, 2000 **2000**
MEDIUM: print
ISSN: 0022-3085
DOCUMENT TYPE: Article
RECORD TYPE: Abstract
LANGUAGE: English

ABSTRACT: Object: Long-standing overt ventriculomegaly in adults (LOVA) is a unique form of hydrocephalus that develops during childhood and manifests symptoms during adulthood. The aim of the present study was to analyze the **specific** **pathophysiological** **characteristics** of LOVA. **Methods** : The specific diagnostic criteria for LOVA include severe ventriculomegaly in adults that is associated with macrocephalus measuring more than two standard deviations in head circumference and/or neuroradiological evidence of a significantly expanded or destroyed sella turcica. Twenty patients who fulfilled these criteria, 14 males and six females, were retrospectively studied. These patients' ages at diagnosis ranged from 15 to 61 years (mean 39.4 years). All had symptoms and/or signs indicating that hydrocephalus first occurred at birth or during infancy in the absence of any known underlying disease. The authors performed a **pathophysiological** study that included **specific** variations of **magnetic** **resonance** (MR) imaging, such as fluid-attenuated inversion recovery and cardiac-gated cine-mode imaging; intracranial pressure (ICP) monitoring; three-dimensional computerized tomography (CT) scanning; and other techniques. Hydrocephalus was caused by aqueductal stenosis in all patients. Severe ventriculomegaly involving the lateral and third ventricles was associated with a marked expansion or destruction of the sella turcica in 17 cases. Cardiac-gated cine-MR imaging did not reveal any significant movements of cerebrospinal fluid in the aqueduct. Three-dimensional CT ventriculography confirmed that the expanded third ventricle protruded into the sella and, sometimes, extended a diverticulum. Fourteen patients revealed symptoms and signs that indicated increased ICP with prominent pressure waves. Dementia or mental retardation was seen in 11 patients, gait disturbance in 12, and urinary incontinence in eight; all three of these symptoms were observed in seven patients. Thirteen patients experienced visual disturbance. Nine patients underwent ventriculoperitoneal shunt implantation as the initial treatment, leading to postoperative subdural hematoma in all seven cases in which a differential pressure valve was used. Nine patients, three of whom were initially treated by shunt placement, underwent a neuroendoscopic **procedure** , mainly for third ventriculostomy. Post-**operatively** , ICP returned to normal, and marked to-and-fro pulsatile movements at the site of ventriculostomy were recognized on cine-MR **imaging** in **patients** treated **endoscopically** . However, the ventriculomegaly was little improved. Consequently, all patients eventually demonstrated improvement in response to either a shunt equipped with a pressure-programmable valve or an **endoscopic** **procedure** ; however, depression appeared in six patients, who required psychiatric consultation or medication. Conclusions: Such remarkably decreased intracranial compliance but relatively high ICP dynamics are the pathophysiological **characteristics** of LOVA. The therapeutic regimen should be determined based on the individual's **specific** **pathophysiological** makeup.

DESCRIPTORS:
MAJOR CONCEPTS: Neurology--Human Medicine, Medical Sciences; Surgery--Medical Sciences
BIOSYSTEMATIC NAMES: Hominidae--Primates, Mammalia, Vertebrata, Chordata, Animalia

ORGANISMS: human (Hominidae)--patient
ORGANISMS: PARTS ETC: sella turcica--skeletal **system**
COMMON TAXONOMIC TERMS: Animals; Chordates; Humans; Mammals; Primates; Vertebrates
DISEASES: dementia--behavioral and mental disorders, nervous **system** disease; depression--behavioral and mental disorders; gait disturbance --nervous **system** disease; hydrocephalus--congenital disease, nervous **system** disease; long-standing overt ventriculomegaly--nervous **system** disease; mental retardation--behavioral and mental disorders, nervous **system** disease; subdural hematoma--nervous **system** disease, vascular disease, postoperative; urinary incontinence--urologic disease; visual disturbance--nervous **system** disease
MESH TERMS: Dementia (MeSH); Depression (MeSH); Hydrocephalus (MeSH); Mental Retardation (MeSH); Hematoma, Subdural (MeSH); Urinary Incontinence (MeSH)
METHODS & EQUIPMENT: computed tomography--diagnostic **method** ; intracranial pressure monitoring--diagnostic **method** ; magnetic resonance imaging--diagnostic **method** , imaging techniques; third ventriculostomy--complications, surgical **method** , therapeutic **method** ; ventriculoperitoneal shunt implantation--complications, surgical **method** , therapeutic **method**
MISCELLANEOUS TERMS: aqueductal stenosis
CONCEPT CODES:
06504 Radiation biology - Radiation and isotope techniques
07004 Behavioral biology - Human behavior
11105 Anatomy and Histology - Surgery
12504 Pathology - Diagnostic
12512 Pathology - Therapy
14508 Cardiovascular system - Blood vessel pathology
15506 Urinary system - Pathology
18004 Bones, joints, fasciae, connective and adipose tissue - Physiology and biochemistry
20506 Nervous system - Pathology
21002 Psychiatry - Psychopathology, psychodynamics and therapy
21006 Psychiatry - Mental retardation
25503 Development and Embryology - Pathology
25552 Development and Embryology - Descriptive teratology and teratogenesis
BIOSYSTEMATIC CODES:
86215 Hominidae

2000

...ABSTRACT: and manifests symptoms during adulthood. The aim of the present study was to analyze the **specific pathophysiological characteristics** of LOVA. **Methods** : The specific diagnostic criteria for LOVA include severe ventriculomegaly in adults that is associated with...

...or during infancy in the absence of any known underlying disease. The authors performed a **pathophysiological** study that included **specific** variations of **magnetic resonance** (MR) imaging, such as fluid-attenuated inversion recovery and cardiac-gated cine-mode imaging; intracranial...

...used. Nine patients, three of whom were initially treated by shunt placement, underwent a neuroendoscopic **procedure** , mainly for third ventriculostomy. Post- **operatively** , ICP returned to normal, and marked to-and-fro pulsatile movements at the site of ventriculostomy were recognized on cine-MR **imaging** in **patients** treated **endoscopically** . However, the ventriculomegaly was little improved. Consequently, all

patients eventually demonstrated improvement in response to either a shunt equipped with a pressure-programmable valve or an **endoscopic procedure** ; however, depression appeared in six patients, who required psychiatric consultation or medication. Conclusions: Such remarkably decreased intracranial compliance but relatively high ICP dynamics are the pathophysiological **characteristics** of LOVA. The therapeutic regimen should be determined based on the individual's **specific pathophysiological** makeup.

DESCRIPTORS:
...ORGANISMS: PARTS ETC: skeletal **system**
...DISEASES: behavioral and mental disorders, nervous **system** disease...

...nervous **system** disease...

...congenital disease, nervous **system** disease...

...nervous **system** disease...

...behavioral and mental disorders, nervous **system** disease...

...nervous **system** disease, vascular disease, postoperative...

...nervous **system** disease
...METHODS & EQUIPMENT: diagnostic **method** ; ...

...diagnostic **method** ; ...

...diagnostic **method** , imaging techniques...
...complications, surgical **method** , therapeutic **method** ; ...

...complications, surgical **method** , therapeutic **method**

31/5,K/4 (Item 3 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

0012569233 BIOSIS NO.: 200000287546
Endoscope system **including** endoscope **and protection cover**
AUTHOR: Yabe Hisao (Reprint); Iida Yoshihiro; Suzuki Akir; Ito Hideo; Tashiro Yoshio; Yamazaki Minoru; Tamada Osamu
AUTHOR ADDRESS: Hachioji, Japan**Japan
JOURNAL: Official Gazette of the United States Patent and Trademark Office Patents 1228 (5): Nov. 30, 1999 **1999**
MEDIUM: e-file
PATENT NUMBER: US 5993380 PATENT DATE GRANTED: November 30, 1999 19991130
PATENT CLASSIFICATION: 600-121 PATENT ASSIGNEE: Olympus Optical Co., Ltd.
PATENT COUNTRY: USA
ISSN: 0098-1133
DOCUMENT TYPE: Patent
RECORD TYPE: Abstract
LANGUAGE: English

ABSTRACT: In an **endoscope system** including an **endoscope** having an **insertion** section to be **inserted** into a cavity under inspection, a **bending** portion which is provided in said **insertion** section near a distal end thereof and is **bendable** in at least two different **directions** and an **operation** section to which a proximal end of the **insertion** section is connected and a disposable protection cover having an **insertion** section cover for covering said **insertion** section of the

endoscope and having formed therein an **insertion** section **inserting** channel into which said **insertion** section of the **endoscope** is **insertable** and at least one conduit channel, said **insertion** section and **bending** portion of the **endoscope** are formed to have a non-circular lateral cross section, a **direction** in which said non-circular cross section has a larger size is aligned with a **direction** in which said **bending** portion is bent by a maximum **bending** **angle** or a **direction** in which said non-circular cross section has a smaller size is aligned with a **direction** in which said **bending** portion is bent by a minimum **bending** **angle** .

DESCRIPTORS:
MAJOR CONCEPTS: Equipment, Apparatus, Devices and Instrumentation; Surgery--Medical Sciences
METHODS & EQUIPMENT: **endoscope** **system** --medical equipment
CONCEPT CODES:
00532 General biology - Miscellaneous

Endoscope system **including** endoscope **and protection cover**
1999

ABSTRACT: In an **endoscope** **system** including an **endoscope** having an **insertion** section to be **inserted** into a cavity under inspection, a **bending** portion which is provided in said **insertion** section near a distal end thereof and is **bendable** in at least two different **directions** and an **operation** section to which a proximal end of the **insertion** section is connected and a disposable protection cover having an **insertion** section cover for covering said **insertion** section of the **endoscope** and having formed therein an **insertion** section **inserting** channel into which said **insertion** section of the **endoscope** is **insertable** and at least one conduit channel, said **insertion** section and **bending** portion of the **endoscope** are formed to have a non-circular lateral cross section, a **direction** in which said non-circular cross section has a larger size is aligned with a **direction** in which said **bending** portion is bent by a maximum **bending** **angle** or a **direction** in which said non-circular cross section has a smaller size is aligned with a **direction** in which said **bending** portion is bent by a minimum **bending** **angle** .
DESCRIPTORS:
METHODS & EQUIPMENT: **endoscope** **system** --

31/5,K/5 (Item 4 from file: 5)
DIALOG(R)File 5:Biosis Previews(R)

0011704204 BIOSIS NO.: 199800498451
Transesophageal biopsy **mediastinal and pulmonary** tumors **by means of** endoscopic **ultrasound guidance**
AUTHOR: Huenerbein Michael; Michael Bijan; Haensch Wolfgang; Schlag Peter M (Reprint)
AUTHOR ADDRESS: Dep. Surgery Surgical Oncology, Robert-Roessle Hospital Tumor Inst., Humboldt Univ., Lindenbergerweg 80, 13122 Berlin, Germany** Germany
JOURNAL: Journal of Thoracic and Cardiovascular Surgery 116 (4): p554-559 Oct., 1998 **1998**
MEDIUM: print
ISSN: 0022-5223
DOCUMENT TYPE: Article

RECORD TYPE: Abstract
LANGUAGE: English

ABSTRACT: Objective: The aim of this study was to investigate the value of **endoscopic** ultrasound- **guided** **biopsy** for the diagnosis of thoracic **lesions** . **Methods** : Transesophageal ultrasound- **guided** **biopsy** was performed in 29 patients with mediastinal (n = 25) or pulmonary **tumors** (n = 4). A flexible echoendoscope with a 7.5 MHz **curved** array transducer (Pentax FG 32 UA, Hamburg, Germany) and a **biopsy** device with a fine needle (**diameter** 0.8 mm) were used for all examinations. Three patients were excluded from the analysis of the data because a definite diagnosis based on surgery or follow-up was not available. Results: Real-time visualization of the **biopsy** **procedure** with **endoscopic** ultrasound enabled accurate tissue sampling even of small mediastinal **lesions** with a **diameter** of less than 1 cm. Diagnostic material was obtained in 23 of the 26 patients (88%). In 3 cases (12%) non-representative **biopsy** material was found in the specimen. The sensitivity and specificity of transesophageal **biopsy** in the diagnosis of malignancy were 89% and 83%, respectively. Histologic analysis of the **biopsy** specimens established malignancy in 17 of 23 patients, whereas benign **lesions** were diagnosed in 6 **patients** . **Endoscopic** **ultrasound** - **guided** **biopsy** confirmed the diagnosis suggested by conventional diagnostic **methods** in 15 of 23 patients (65%), whereas an unsuspected diagnosis was disclosed in 8 patients (35%). The results of the **biopsy** had considerable impact on the therapeutic strategy. None of the patients had complications related to the **procedure** . Conclusions: Endoscopic ultrasound- **guided** **biopsy** provides a new minimally invasive approach to the **biopsy** of **lesions** in the posterior mediastinum and may complement surgical staging **procedures** .

DESCRIPTORS:
  MAJOR CONCEPTS: Equipment, Apparatus, Devices and Instrumentation; Oncology--Human Medicine, Medical Sciences
  BIOSYSTEMATIC NAMES: Hominidae--Primates, Mammalia, Vertebrata, Chordata, Animalia
  ORGANISMS: human (Hominidae)--female, patient, male
  COMMON TAXONOMIC TERMS: Animals; Chordates; Humans; Mammals; Primates; Vertebrates
  DISEASES: mediastinal **tumors** --neoplastic disease; pulmonary **tumors** --neoplastic disease, respiratory **system** disease; thoracic **lesions** --disease-miscellaneous, diagnosis
  METHODS & EQUIPMENT: echoendoscope--7.5 MHz **curved** array transducer, medical equipment, flexible; **endoscopic** ultrasound- **guided** transesophageal **biopsy** --diagnostic **method** , minimal invasive; surgery--surgical **method** , therapeutic **method**

CONCEPT CODES:
  24002 Neoplasms - General
  10504 Biophysics - Methods and techniques
  11105 Anatomy and Histology - Surgery
  12504 Pathology - Diagnostic
  12512 Pathology - Therapy

BIOSYSTEMATIC CODES:
  86215 Hominidae

Transesophageal biopsy **mediastinal and pulmonary** tumors **by means of** endoscopic **ultrasound guidance**
1998

ABSTRACT: Objective: The aim of this study was to investigate the value of **endoscopic** ultrasound- **guided** **biopsy** for the diagnosis of thoracic **lesions** . **Methods** : Transesophageal ultrasound- **guided** **biopsy** was

performed in 29 patients with mediastinal (n = 25) or pulmonary **tumors** (n = 4). A flexible echoendoscope with a 7.5 MHz **curved** array transducer (Pentax FG 32 UA, Hamburg, Germany) and a **biopsy** device with a fine needle (**diameter** 0.8 mm) were used for all examinations. Three patients were excluded from the analysis...

...based on surgery or follow-up was not available. Results: Real-time visualization of the **biopsy procedure** with **endoscopic** ultrasound enabled accurate tissue sampling even of small mediastinal **lesions** with a **diameter** of less than 1 cm. Diagnostic material was obtained in 23 of the 26 patients (88%). In 3 cases (12%) non-representative **biopsy** material was found in the specimen. The sensitivity and specificity of transesophageal **biopsy** in the diagnosis of malignancy were 89% and 83%, respectively. Histologic analysis of the **biopsy** specimens established malignancy in 17 of 23 patients, whereas benign **lesions** were diagnosed in 6 **patients** . **Endoscopic ultrasound - guided biopsy** confirmed the diagnosis suggested by conventional diagnostic **methods** in 15 of 23 patients (65%), whereas an unsuspected diagnosis was disclosed in 8 patients (35%). The results of the **biopsy** had considerable impact on the therapeutic strategy. None of the patients had complications related to the **procedure** . Conclusions: Endoscopic ultrasound- **guided biopsy** provides a new minimally invasive approach to the **biopsy** of **lesions** in the posterior mediastinum and may complement surgical staging **procedures** .

DESCRIPTORS:

DISEASES: mediastinal **tumors** --...

...pulmonary **tumors** --...

...neoplastic disease, respiratory **system** disease...

...thoracic **lesions** --

...METHODS & EQUIPMENT: 7.5 MHz curved array transducer, medical equipment, flexible...

... **endoscopic** ultrasound- **guided** transesophageal **biopsy** --...

...diagnostic **method** , minimal invasive...

...surgical **method** , therapeutic **method**

31/5,K/6 (Item 1 from file: 8)

DIALOG(R)File 8:Ei Compendex(R)

05403229 E.I. No: E2099104861632

Title: Depth **map based scene analysis for active** navigation

Author: Bellemare, Marc-Emmanuel; Haigron, Pascal; Lucas, Antoine; Coatrieux, Jean-Louis

Corporate Source: Universite de Rennes 1, Rennes, Fr

Conference Title: Proceedings of the 1999 Medical Imaging - Physiology and Function from Multidimensional Images

Conference Location: San Diego, CA, USA Conference Date: 19990221-19990223

Sponsor: SPIE

E.I. Conference No.: 55284

Source: Proceedings of SPIE - The International Society for Optical Engineering v 3660 1999. p 202-213

Publication Year: 1999

CODEN: PSISDG ISSN: 0277-786X

Language: English
Document Type: JA; (Journal Article)   Treatment: T; (Theoretical)
Journal Announcement: 9912W1
Abstract: Three dimensional volume data sets provided by CT or MRI allow the user to move virtually around within **anatomic structures** and to observe them. We propose a new **method** to **guide** the path planning based on the local image interpretation during the **navigation** inside the **anatomic structures** with cavities, without preprocessing for 3D volume data sets. Thanks to the scene analysis **process**, the virtual sensor constructs by itself a model of the unknown scene. Qualitative and quantitative characterization of the **anatomic structures**, derived from this exploration, is of main interest in such a new application of virtual **endoscopy** that is vascular surgery. In this paper we especially describe the scene analysis **process** which is based on the **processing** of the **depth** map directly produced by the ray casting **procedure**. Application to vascular surgery, i.e. virtual angioscopy, is then depicted. (Author abstract) 9 Refs.
Descriptors: Medical imaging; Computerized tomography; **Magnetic resonance imaging**; Image analysis; **Virtual** reality; **Endoscopy**; Motion **planning**
Identifiers: Scene analysis; Active **navigation**; Virtual **endoscopy**; Vascular surgery; **Depth** map **processing**
Classification Codes:
461.1 (Biomedical Engineering); 723.5 (Computer Applications); 701.2 (Magnetism: Basic Concepts & Phenomena); 461.6 (Medicine)
461 (Biotechnology); 741 (Optics & Optical Devices); 723 (Computer Software); 701 (Electricity & Magnetism)
46 (BIOENGINEERING); 74 (OPTICAL TECHNOLOGY); 72 (COMPUTERS & DATA PROCESSING); 70 (ELECTRICAL ENGINEERING)

Title: Depth **map based scene analysis for active** navigation
...Abstract: data sets provided by CT or MRI allow the user to move virtually around within **anatomic structures** and to observe them. We propose a new **method** to **guide** the path planning based on the local image interpretation during the **navigation** inside the **anatomic structures** with cavities, without preprocessing for 3D volume data sets. Thanks to the scene analysis **process**, the virtual sensor constructs by itself a model of the unknown scene. Qualitative and quantitative characterization of the **anatomic structures**, derived from this exploration, is of main interest in such a new application of virtual **endoscopy** that is vascular surgery. In this paper we especially describe the scene analysis **process** which is based on the **processing** of the **depth** map directly produced by the ray casting **procedure**. Application to vascular surgery, i.e. virtual angioscopy, is then depicted. (Author abstract) 9 Refs.
Descriptors: Medical imaging; Computerized tomography; **Magnetic resonance imaging**; Image analysis; **Virtual** reality; **Endoscopy**; Motion **planning**
Identifiers: Scene analysis; Active **navigation**; Virtual **endoscopy**; Vascular surgery; **Depth** map **processing**

31/5,K/7 (Item 1 from file: 34)
DIALOG(R)File 34:SciSearch(R) Cited Ref Sci

09153687 Genuine Article#: 373KP Number of References: 13
Title: Evaluation of real-time imaging using a laparoscopic ultrasound probe during operative endoscopic procedures

Author(s): Letterie GS (REPRINT) ; Marshall L
Corporate Source: VIRGINIA MASON MED CTR,CTR FERTIL & REPROD ENDOCRINOL, 1100 9TH AVE, FC 11/SEATTLE//WA/98110 (REPRINT)
Journal: ULTRASOUND IN OBSTETRICS & GYNECOLOGY, **2000** , V16, N1 (JUL), P 63-67
ISSN: 0960-7692 Publication date: 20000700
Publisher: BLACKWELL SCIENCE LTD, P O BOX 88, OSNEY MEAD, OXFORD OX2 ONE, OXON, ENGLAND
Language: English Document Type: ARTICLE
Geographic Location: USA
Subfile: CC CLIN--Current Contents, Clinical Medicine
Journal Subject Category: ACOUSTICS; OBSTETRICS & GYNECOLOGY; RADIOLOGY, NUCLEAR MEDICINE & MEDICAL IMAGING
Abstract: Objectives To evaluate rigid and flexible ultrasound transducers introduced through a laparoscopic port to image pelvic anatomy during **operative** **endoscopy** as a means of mapping the pelvic anatomy, detecting pathology, and for real-time tracking of intra-uterine **procedures** .

Design Prospective, descriptive, non-comparative.

Materials and **methods** Laparoscopy, hysteroscopy and real-time, gray-scale ultrasonography were preformed simultaneously in 36 **patients** . Laparoscopic **ultrasound** was performed using 10 mm **diameter** , 7.5 MHz gray-scale rigid and steerable transducers for imaging of the ovaries and uterus during **operative** **endoscopy** (Aloka, Wallingford, **CT** , USA). All **patients** underwent intra- **operative** evaluation using this probe to assess uterine and ovarian structures and to track instruments intra- **operatively** during complex intra-uterine hysteroscopic **procedures** and for intra- **operative** sonohysterography.

Results Laparoscopic ultrasound provided visualization of structures and delineation of ovarian anatomy needle placement for tracking microscissors and intra- **operative** sonohysterography. The ultrasonography provided information useful for determining the configuration of normal **anatomic** **structures** , the localization of and more precise incision placement for anatomic abnormalities and for intra- **operative** guidance during hysteroscopic resection of intra-uterine adhesions. The imaging also provided details of intra-uterine anatomy through sonohysterography performed during chromotubation. However, no additional information regarding ovarian or uterine abnormalities was noted beyond that detected on pre- **operative** transvaginal ultrasonography. No technical problems were encountered. No additional **operative** time was required.

Conclusions Real-time laparoscopic ultrasound imaging is useful in monitoring complex intra-uterine **operative** **procedures** and in detailing intra-uterine anatomy during intra- **operative** sonohysterography. However, it did not provide more enhanced imaging of ovarian anatomy beyond images obtained with pre- **operative** transvaginal imaging. This imaging technique may have broad application for a variety of **endoscopic** **operative** **procedures** with the potential to impact on **operative** decision-making and requires further evaluation.
Descriptors--Author Keywords: **endoscopic** ultrasound ; hysteroscopy ; laparoscopy
Identifiers--KeyWord Plus(R): ULTRASONOGRAPHY; GUIDANCE; SURGERY; URETER
Cited References:
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CALERY NP, 1997, V185, P33, J AM COLL SURGEONS

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HUNERBEIN M, 1995, V21, P50, EUR J SURG ONCOL
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STIGMAN JB, 1994, V8, P167, SURG ENDOSC-ULTRAS
VANSTIGMANN G, 1995, V5, P869, GASTROINTEST ENDOSC

Title: Evaluation of real-time imaging using a laparoscopic ultrasound probe during operative endoscopic procedures
, **2000**

...Abstract: rigid and flexible ultrasound transducers introduced through a laparoscopic port to image pelvic anatomy during **operative endoscopy** as a means of mapping the pelvic anatomy, detecting pathology, and for real-time tracking of intra-uterine **procedures** .

Design Prospective, descriptive, non-comparative.

Materials and **methods** Laparoscopy, hysteroscopy and real-time, gray-scale ultrasonography were preformed simultaneously in 36 **patients** . Laparoscopic **ultrasound** was performed using 10 mm **diameter** , 7.5 MHz gray-scale rigid and steerable transducers for imaging of the ovaries and uterus during **operative endoscopy** (Aloka, Wallingford, **CT** , USA). All **patients** underwent intra- **operative** evaluation using this probe to assess uterine and ovarian structures and to track instruments intra- **operatively** during complex intra-uterine hysteroscopic **procedures** and for intra- **operative** sonohysterography.

Results Laparoscopic ultrasound provided visualization of structures and delineation of ovarian anatomy needle placement for tracking microscissors and intra- **operative** sonohysterography. The ultrasonography provided information useful for determining the configuration of normal **anatomic structures** , the localization of and more precise incision placement for anatomic abnormalities and for intra- **operative** guidance during hysteroscopic resection of intra-uterine adhesions. The imaging also provided details of intra...

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Conclusions Real-time laparoscopic ultrasound imaging is useful in monitoring complex intra-uterine **operative procedures** and in detailing intra-uterine anatomy during intra- **operative** sonohysterography. However, it did not provide more enhanced imaging of ovarian anatomy beyond images obtained with pre- **operative** transvaginal imaging. This imaging technique may have broad application for a variety of **endoscopic operative procedures** with the potential to impact on **operative** decision-making and requires further evaluation.

31/5,K/8 (Item 2 from file: 34)
DIALOG(R)File 34:SciSearch(R) Cited Ref Sci

08679656 Genuine Article#: 316NC Number of References: 11

Title: Neuroendoscopy combined with frameless neuronavigation

Author(s): Gumprecht H (REPRINT) ; Trost HA; Lumenta CB
Corporate Source: TECH UNIV MUNICH,KRANKENHAUS MUNCHEN BOGENHAUSEN, DEPT NEUROSURG, ENGLSCHALKINGERSTR 77/D-81925 MUNICH//GERMANY/ (REPRINT)

Journal: BRITISH JOURNAL OF NEUROSURGERY, **2000** , V14, N2 (APR), P129-131
ISSN: 0268-8697 Publication date: 20000400
Publisher: CARFAX PUBLISHING, RANKINE RD, BASINGSTOKE RG24 8PR, HANTS, ENGLAND
Language: English Document Type: ARTICLE
Geographic Location: GERMANY
Subfile: CC CLIN--Current Contents, Clinical Medicine
Journal Subject Category: CLINICAL NEUROLOGY; SURGERY

Abstract: Minimal invasive neurosurgery is becoming more and more standard in neurosurgical **procedures** . Several types of **lesions** are now approached **endoscopically** . The surgical planning and intraoperative orientation during **endoscopic** surgical **procedures** are sometimes difficult. To solve this problem, a combination of the **endoscopic procedure** with a frameless, armless neuronavigation **system** is used in our service. The combination of the **endoscope** and the frameless **navigation system** was used in **tumour** surgery, ventriculostomies and arachnoid cyst **operations** . All **procedures** were performed successfully. The combination of both **systems** has proved to be advantageous because of safe surgical planning using the frameless stereotactic technique and the possibility of real time orientation of the **endoscope** . This technique is very useful in removing intraventricular and large brain mass **lesions** .

Descriptors--Author Keywords: frameless stereotaxy ; neuroendoscopy ; neuronavigation
Identifiers--KeyWord Plus(R): TECHNICAL NOTE; STEREOTAXY; ARM

Cited References:

BARNETT GH, 1993, V78, P510, J NEUROSURG
GERMANO IM, 1995, V37, P348, NEUROSURGERY
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GUMPRECHT HK, 1997, P1581, 11 INT C NEUR SURG A
MANWARING KH, 1994, V61, P34, ACT NEUR S
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SPETZGER U, 1995, V38, P163, MINIM INVAS NEUROSUR
WATANABE E, 1991, V28, P792, NEUROSURGERY

, **2000**

Abstract: Minimal invasive neurosurgery is becoming more and more standard in neurosurgical **procedures** . Several types of **lesions** are now approached **endoscopically** . The surgical planning and intraoperative orientation during **endoscopic** surgical **procedures** are sometimes difficult. To solve this problem, a combination of the **endoscopic procedure** with a frameless, armless neuronavigation **system** is used in our service. The combination of the **endoscope** and the frameless **navigation system** was used in **tumour** surgery, ventriculostomies and arachnoid cyst **operations** . All **procedures** were performed successfully. The combination of both **systems** has proved to be advantageous because of safe surgical planning using the frameless stereotactic technique and the possibility of real time orientation of the **endoscope** . This technique is very useful in removing intraventricular and large brain mass **lesions** .

31/5,K/9 (Item 3 from file: 34)
DIALOG(R)File 34:SciSearch(R) Cited Ref Sci

06284010 Genuine Article#: YG292 Number of References: 13
Title: Granulomatous reaction to a foreign body mimicking bronchogenic tumor . CT **findings with** virtual endoscopy
Author(s): Mignon F (REPRINT) ; Mesurolle B; Chambellan A; Duboucher C; DangeardChikhani S; Leclerc P; Lemesle J
Corporate Source: CTR HOSP,SERV RADIOL PNEUMOL & ANATOMOPATHOL, 20 RUE AMAGIS/F-78100 ST GERMAIN EN LAYE//FRANCE/ (REPRINT)
Journal: JOURNAL DE RADIOLOGIE, **1997** , V78, N11 (NOV), P1181-1184
ISSN: 0221-0363 Publication date: 19971100
Publisher: MASSON EDITEUR, 120 BLVD SAINT-GERMAIN, 75280 PARIS 06, FRANCE
Language: French Document Type: ARTICLE
Geographic Location: FRANCE
Subfile: CC CLIN--Current Contents, Clinical Medicine
Journal Subject Category: RADIOLOGY, NUCLEAR MEDICINE & MEDICAL IMAGING
Abstract: The aim of this study is to report the spiral CT findings of an endobronchial foreign body (chicken's bone) unknown on the posteroanterior chest radiograph and on the first **bronchoscopy** . The double originality of this case is the association with endobronchial actinomycosis mimicking a bronchial neoplasm and the utilization of virtual **endoscopy** by endoluminal 3D reconstruction in this context which has never been reported.

The endoluminal 3D reconstruction of the bronchial tree could help **guide** the **endoscopic procedure** by better localization of the **lesions** .
Descriptors--Author Keywords: bronchus ; airway foreign body ; actinomycosis ; helical CT ; 3D
Identifiers--KeyWord Plus(R): ENDOBRONCHIAL ACTINOMYCOSIS; COMPUTED-TOMOGRAPHY; **BRONCHOSCOPY**
Cited References:
ARIEL I, 1991, V99, P493, CHEST
BERGER PE, 1980, V134, P133, RADIOLOGY
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PAZ HL, 1992, V101, P1160, CHEST
PIGUET JJ, 1981, V30, P503, J FR OTORHINOLARYNG
POEY C, 1996, V77, P177, J RADIOL
Title: Granulomatous reaction to a foreign body mimicking bronchogenic tumor . CT **findings with** virtual endoscopy
, **1997**
...Abstract: foreign body (chicken's bone) unknown on the posteroanterior chest radiograph and on the first **bronchoscopy** . The double originality of this case is the association with endobronchial actinomycosis mimicking a bronchial neoplasm and the utilization of virtual **endoscopy** by endoluminal 3D reconstruction in this context which has never been reported.

The endoluminal 3D reconstruction of the bronchial tree could help **guide** the **endoscopic procedure** by better localization of the **lesions** .
...Identifiers--ENDOBRONCHIAL ACTINOMYCOSIS; COMPUTED-TOMOGRAPHY;

BRONCHOSCOPY

31/5,K/10 (Item 4 from file: 34)
DIALOG(R)File 34:SciSearch(R) Cited Ref Sci

06154389 Genuine Article#: BJ58E Number of References: 18
Title: Non-invasive 3D patient **registration for** image - guided **intranasal surgery - Experimental and clinical results**
Author(s): Hauser R (REPRINT) ; Westermann B; Probst R
Corporate Source: UNIV BASEL,KANTONSSPITAL, DEPT OTORHINOLARYNGOL/CH-4031 BASEL//SWITZERLAND/ (REPRINT)
, **1997** , V1205, P327-336
ISSN: 0302-9743 Publication date: 19970000
Publisher: SPRINGER-VERLAG BERLIN, HEIDELBERGER PLATZ 3, W-1000 BERLIN 33, GERMANYLECTURE NOTES IN COMPUTER SCIENCE
Series: LECTURE NOTES IN COMPUTER SCIENCE
Language: English Document Type: ARTICLE
Geographic Location: SWITZERLAND
Journal Subject Category: COMPUTER SCIENCE, THEORY & METHODS
Abstract: Image- **guided** , computer-assisted surgery **systems** base on a common reference between the pre- **operative** image data and the corresponding **patient** **pathology** . Therefore, accurate 3D **patient** registration and referencing is necessary. Considering that during **image** data acquisition **patient** misalignment and movement can arise in three dimensions, an automatic image registration **method** must base on a three-dimensional approach. Our **method** provides non-invasive 3D patient registration for correction of such movement errors during data acquisition and active referencing to update the position of the patient's head during surgery. Experimental data concerning the accuracy of repeated positionings of our patient registration and reference **system** demonstrated an accuracy with mean spatial errors of 0.82 mm +/- 0.31 mm in a plastic skull and 1.39 mm +/- 0.61 mm in patients, respectively. Results suggest that non-invasive 3D **patient** registration for **image - guided** surgery may be a precise and useful **method** for computer-assisted identification of **anatomical structures** . Clinical experiences for different **pathologies** are presented (30 **patients**).
Identifiers--KeyWord Plus(R): **ENDOSCOPIC** SINUS SURGERY; LOCALIZATION; DIGITIZER; ACCURACY; **SYSTEM**
Cited References:
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WESTERMANN B, 1996, IN PRESS COMPUTERS G
ZINREICH SJ, 1993, V188, P735, RADIOLOGY

Title: Non-invasive 3D patient **registration for** image - guided **intranasal surgery - Experimental and clinical results**
, **1997**

Abstract: Image- **guided** , computer-assisted surgery **systems** base on a common reference between the pre- **operative** image data and the corresponding **patient** **pathology** . Therefore, accurate 3D **patient** registration and referencing is necessary. Considering that during **image** data acquisition **patient** misalignment and movement can arise in three dimensions, an automatic image registration **method** must base on a three-dimensional approach. Our **method** provides non-invasive 3D patient registration for correction of such movement errors during data acquisition...

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...1.39 mm +/- 0.61 mm in patients, respectively. Results suggest that non-invasive 3D **patient** registration for **image - guided** surgery may be a precise and useful **method** for computer-assisted identification of **anatomical** **structures** . Clinical experiences for different **pathologies** are presented (30 **patients**).
...Identifiers-- **ENDOSCOPIC** SINUS SURGERY; LOCALIZATION; DIGITIZER; ACCURACY; **SYSTEM**

31/5,K/11 (Item 1 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

11662909 99097846 PMID: 9881171
Computer-assisted **surgical** navigation **with a dynamic mobile framework for the nasal fossae, sinuses and base of the skull]**
Navigation chirurgicale assistee par ordinateur avec "cadre mobile dynamique" pour les fosses nasales, les sinus et la base du crane.
Caversaccio M; Ladrach K; Bachler R; Schroth G; Nolte L P; Hausler R
Clinique Universitaire d'ORL et de Chirurgie Cervico-Maxillo-Faciale, Hopital de l'Ile, CH-3010, Berne.
Annales d'oto-laryngologie et de chirurgie cervico faciale - bulletin de la Societe d'oto-laryngologie des hopitaux de Paris (FRANCE) Nov **1998** , 115 (5) p253-8, ISSN 0003-438X Journal Code: 9431026
Document type: Journal Article ; English Abstract
Languages: FRENCH
Main Citation Owner: NLM
Record type: Completed
Subfile: INDEX MEDICUS
Surgery of the skull base and of the paranasal sinuses is often difficult because of the complex anatomy and the delicate structures; serious complications (loss of vision, cerebral **lesion**) have been reported. To improve the safety of such **operations** , computer-assisted **navigation** surgery is increasingly being put to use. We introduce the **system** which was developed in Berne. Our computer-assisted **system** is based on an intraoperative pursuit of the head and instruments which are equipped with infrared diodes and registered by an opto-electronic **system** -camera. The CT-acquisition of the head is accomplished framelessly without a head-holding device. This allows free movement of the head during surgery. Between March and November 1997, 35 **navigation** **operations** were performed for various pathologies at the anterior and lateral skull base.

The majority of the cases were endonasal **operations** . No surgical complications occurred inspite of the complexity of the **operations** . The measured accuracy of the **system** between the CT and the actual instrument location in the patient was 0.5-2 mm (mean : < 1 mm) for the anterior skull base and 1-2.5 mm (mean < 1.5 mm) for the lateral skull base. The intraoperative **navigation system** allows identification of essential **anatomical structures** and permits safe and efficient surgery without additional loss of time. In addition, such a **system** allows minimal invasive approaches, and new **operations** may become possible.

Tags: Case Report; Female; Human; Male

Descriptors: Computer **Systems** ; *Nose--surgery--SU; *Paranasal Sinuses --surgery--SU; *Skull Base--surgery--SU; *Therapy, Computer-Assisted; *User-Computer Interface; Adult; Cerebrospinal Fluid Rhinorrhea--surgery --SU; Electronics, Medical--instrumentation--IS; **Endoscopes** ; **Endoscopy -- methods** --MT; Ethmoid Sinus--surgery--SU; Ethmoid Sinusitis--surgery--SU ; Image **Processing** , Computer-Assisted; Intraoperative Care; Middle Age; Optics--instrumentation--IS; Radiology Information **Systems** ; Safety; Sphenoid Sinus--surgery--SU; Surgical **Procedures** , Minimally Invasive; Therapy, Computer-Assisted--instrumentation--IS; Therapy, Computer-Assiste d-- **methods** --MT; Tomography, X-Ray Computed

Record Date Created: 19990122

Record Date Completed: 19990122

Computer-assisted surgical navigation **with a dynamic mobile framework for the nasal fossae, sinuses and base of the skull]**

Navigation chirurgicale assistee par ordinateur avec "cadre mobile dynamique" pour les fosses nasales, les sinus et...

Nov **1998** ,

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...1-2.5 mm (mean < 1.5 mm) for the lateral skull base. The intraoperative **navigation system** allows identification of essential **anatomical structures** and permits safe and efficient surgery without additional loss of time. In addition, such a **system** allows minimal invasive approaches, and new **operations** may become possible.

Descriptors: Computer **Systems** ; *Nose--surgery--SU; *Paranasal Sinuses --surgery--SU; *Skull Base--surgery--SU; *Therapy, Computer-Assisted; *User ...

; Adult; Cerebrospinal Fluid Rhinorrhea--surgery--SU; Electronics, Medical --instrumentation--IS; **Endoscopes** ; **Endoscopy -- methods** --MT; Ethmoid Sinus--surgery--SU; Ethmoid Sinusitis--surgery--SU; Image **Processing** , Computer-Assisted; Intraoperative Care; Middle Age; Optics--instrumentation --IS; Radiology Information **Systems** ; Safety; Sphenoid Sinus--surgery--SU; Surgical **Procedures** , Minimally Invasive; Therapy, Computer-Assisted --instrumentation--IS; Therapy, Computer-Assisted-- **methods** --MT;

Tomography, X-Ray Computed

31/5,K/12 (Item 2 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

11282361 98160940 PMID: 9499960
Foreign body granuloma mimicking bronchial tumor . **Aspects in x-ray computed** tomography **with views by** virtual endoscopy]
Granulome a corps etranger mimant une tumeur bronchique. Aspects en TDM avec vue par **endoscopie** virtuelle.
Mignon F; Mesurolle B; Chambellan A; Duboucher C; Dangeard-Chikhani S; Leclerc P; Lemesle J
Service de Radiologie, de Pneumologie et d'Anatomopathologie, Centre Hospitalier, Saint-Germain-en-Laye.
Journal de radiologie (FRANCE) Nov **1997** , 78 (11) p1181-4, ISSN 0221-0363 Journal Code: 7906266
Document type: Journal Article ; English Abstract
Languages: FRENCH
Main Citation Owner: NLM
Record type: Completed
Subfile: INDEX MEDICUS
The aim of this study is to report the spiral CT findings of an endobronchial foreign body (chicken's bone) unknown on the postero-anterior chest radiograph and on the first **bronchoscopy** . The double originality of this case is the association with endobronchial actinomycosis mimicking a bronchial neoplasm and the utilization of virtual **endoscopy** by endoluminal 3D reconstruction in this context which has never been reported. The endoluminal 3D reconstruction of the bronchial tree could help **guide** the **endoscopic procedure** by better localization of the **lesions** .
Tags: Case Report; Human; Male
Descriptors: *Bronchi; *Granuloma, Foreign-Body--radiography--RA; *Tomography, X-Ray Computed; Bronchial Neoplasms--diagnosis--DI; Bronchial Neoplasms--radiography--RA; Carcinoma--diagnosis--DI; Carcinoma--radiography--RA; Diagnosis, Differential; Granuloma, Foreign-Body--diagnosis--DI; Middle Age
Record Date Created: 19980325
Record Date Completed: 19980325

Foreign body granuloma mimicking bronchial tumor . **Aspects in x-ray computed** tomography **with views by** virtual endoscopy]
Granulome a corps etranger mimant une tumeur bronchique. Aspects en TDM avec vue par **endoscopie** virtuelle.
Nov **1997** ,
...body (chicken's bone) unknown on the postero-anterior chest radiograph and on the first **bronchoscopy** . The double originality of this case is the association with endobronchial actinomycosis mimicking a bronchial neoplasm and the utilization of virtual **endoscopy** by endoluminal 3D reconstruction in this context which has never been reported. The endoluminal 3D reconstruction of the bronchial tree could help **guide** the **endoscopic procedure** by better localization of the **lesions** .

31/5,K/13 (Item 3 from file: 155)
DIALOG(R)File 155:MEDLINE(R)

08873811 20159653 PMID: 10695330

Endoscopic **endonasal surgery with image-guidance]**

Otori N; Haruna S; Yoshiyuki M; Moriyama H
Department of Otorhinolaryngology, Jikei University Hospital, Tokyo.

Nippon Jibiinkoka Gakkai kaiho (JAPAN) Jan **2000** , 103 (1) p1-6, ISSN 0030-6622 Journal Code: 7505728
Document type: Clinical Trial; Journal Article ; English Abstract
Languages: JAPANESE
Main Citation Owner: NLM
Record type: Completed
Subfile: INDEX MEDICUS

We evaluated the advantages and disadvantages of image- **guided endoscopic** endonasal surgery for various diseases. Thirty-three patients, including 8 with chronic sinusitis, 14 with paranasal cysts, 1 with paranasal **tumor** (**biopsy**), 1 with sellaturcial cyst (Rathke's cleft cyst) and 9 with pituitary **tumors** were endonasally **operated** on from September 1998 to May 1999, with an electromagnetic **navigation system** , The Insta Trak (Visualization Technology Inc. USA). The Insta Trak **system** is composed of a computer, a metal probe with a nonmetallic suction tube attachment, and a soft-type headset with an electromagnetic sensor. This freehand, armless **system** compensates well for patient's head movement during surgery, and precludes the need for head fixation. Either straight or **curved** suction tube (probe) can be used to access almost of all pathological sites in the sinus cavity. Location of the metal probe is displayed on the computer moniter as an intersection point on the axial, coronal and sagital CT images. In all cases, Insta Trak showed the surgeon the appropriate location and **direction** of each **lesion** . The Insta Trak also indicated the location of the orbit, optic canal, nasolacrimal duct and/or skull base, thus, preventing intraoperative complications. When the anatomy was distorted by previous surgery and/or when there was, uncontrollable bleeding from a severe **lesion** so that the surgeon had difficulty finding the proper orientation, the usefulness of image- **guided** surgery was sufficiently recognized. However, the following disadvantages were also pointed out. An additional 15 to 20 minutes is needed for equipment set up and **operation** , unless the surgeon and the **operation** room staff are familiar with the machine. The **patient** 's **CT image** used for **navigation** relies on data obtained preoperatively, that is to say, it can not reflect morphological changes produced during surgery. Moreover, the surgeon must consider possible errors of the **navigational** point that may result in the headset during surgery, as well as, errors the machine may originally possess. The image- **guided system** successfully integrated the most up-to-date computer technology with a surgeon's anatomical knowledge for improved treatment of **endoscopic** endonasal surgery. However, we also concluded that the **system** should be used as a surgical supporting device for safer and more adequate **procedures** .

Tags: Human
Descriptors: **Endoscopy** -- **methods** --MT; *Image **Processing** , Computer-Assisted--instrumentation--IS; *Nose Diseases--surgery--SU
Record Date Created: 20000405
Record Date Completed: 20000405

Endoscopic **endonasal surgery with image-guidance]**
Jan **2000** ,
We evaluated the advantages and disadvantages of image- **guided endoscopic** endonasal surgery for various diseases. Thirty-three patients, including 8 with chronic sinusitis, 14 with paranasal cysts, 1 with paranasal **tumor** (**biopsy**), 1 with sellaturcial cyst (Rathke's cleft cyst) and 9 with pituitary **tumors** were endonasally **operated** on from September 1998 to May 1999, with an electromagnetic **navigation system** , The Insta Trak (Visualization Technology Inc. USA). The Insta Trak **system** is composed of a computer, a metal probe with a nonmetallic suction tube

attachment, and a soft-type headset with an electromagnetic sensor. This freehand, armless **system** compensates well for patient's head movement during surgery, and precludes the need for head fixation. Either straight or **curved** suction tube (probe) can be used to access almost of all pathological sites in the...

... sagital CT images. In all cases, Insta Trak showed the surgeon the appropriate location and **direction** of each **lesion** . The Insta Trak also indicated the location of the orbit, optic canal, nasolacrimal duct and...

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Descriptors: **Endoscopy** -- **methods** --MT; *Image **Processing** , Computer-Assisted--instrumentation--IS; *Nose Diseases--surgery--SU

31/5,K/14 (Item 1 from file: 73)
DIALOG(R)File 73:EMBASE

10573814 EMBASE No: 2000038764
Frameless neuronavigation applied to endoscopic **neurosurgery**
Hopf N.J.; Grunert P.; Darabi K.; Busert C.; Bettag M.
Dr. N.J. Hopf, Department of Neurosurgery, University of Mainz, Langenbeckstrasse 1, D-55131 Mainz Germany
AUTHOR EMAIL: hopf@nc.klinik.uni-mainz.de
Minimally Invasive Neurosurgery (MINIMALLY INVASIVE NEUROSURG.) (Germany) 1999, 42/4 (187-193)
CODEN: MINUE ISSN: 0946-7211
DOCUMENT TYPE: Journal; Article
LANGUAGE: ENGLISH SUMMARY LANGUAGE: ENGLISH
NUMBER OF REFERENCES: 44

Objective: We retrospectively analyzed the indications, surgical techniques, and applicability of frameless neuronavigation to **endoscopic** **procedures** in a heterogeneous group of 15 patients. Material and **Methods** : In 8 patients indications for surgery were cystic **lesions** , in 3 patients intraventricular **tumors** , and in 4 patients occlusive hydrocephalus. The mean age was 39 years (range 9-76 years). The follow-up period ranged from 5-24 months (mean 10 months). Frameless neuronavigation was accomplished with the ' **operating** arm **system** ' in 10 cases and with the 'optical tracking **system** ' in 5 cases (RADIONICS, Burlington, USA). Results: In all 15 cases, neuronavigation sufficiently provided anatomical **orientation** , **preoperative** **planning** , and intraoperative realization of the approach. The calculated mean calibration error was 2.1 min. There have been no permanent morbidities and no mortalities related to the use of

endoscopes and neuronavigation. Conclusion: In **endoscopic** neurosurgery, frameless neuronavigation is a useful tool in planning and realizing the approach and improving intraoperative orientation in selected cases. Indications are small or hidden **lesions** , impaired visual conditions, abnormal anatomy, and narrow ventricles. **Endoscopic procedures** include fenestration and resection of intraventricular or intraparenchymal cysts, **biopsy** of intraventricular **tumors** , and third ventriculostomy in selected cases.

DEVICE MANUFACTURER NAMES: Radionics/United States
MEDICAL DESCRIPTORS:
* **endoscopic** surgery; *neurosurgery
hydrocephalus--diagnosis--di; hydrocephalus--surgery--su; brain **tumor** --diagnosis--di; brain **tumor** --surgery--su; **preoperative** evaluation; computer assisted **tomography** ; nuclear magnetic resonance imaging; treatment planning; surgical equipment; brain third ventricle; **endoscopy** ; human; male; female; clinical article; adolescent; aged; child; adult; article
SECTION HEADINGS:
008 Neurology and Neurosurgery
014 Radiology
027 Biophysics, Bioengineering and Medical Instrumentation

Frameless neuronavigation applied to endoscopic **neurosurgery**

Objective: We retrospectively analyzed the indications, surgical techniques, and applicability of frameless neuronavigation to **endoscopic procedures** in a heterogeneous group of 15 patients. Material and **Methods** : In 8 patients indications for surgery were cystic **lesions** , in 3 patients intraventricular **tumors** , and in 4 patients occlusive hydrocephalus. The mean age was 39 years (range 9-76...

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MEDICAL DESCRIPTORS:
* **endoscopic** surgery; *neurosurgery
hydrocephalus--diagnosis--di; hydrocephalus--surgery--su; brain **tumor** --diagnosis--di; brain **tumor** --surgery--su; **preoperative** evaluation; computer assisted **tomography** ; nuclear magnetic resonance imaging; treatment planning; surgical equipment; brain third ventricle; **endoscopy** ; human; male; female; clinical article; adolescent; aged; child; adult; article
1999

31/5,K/15 (Item 2 from file: 73)
DIALOG(R)File 73:EMBASE

07273896 EMBASE No: 1998186084

Therapy of carpal tunnel syndrome

THERAPIE DES KARPALTUNNELSYNDROMS

Klauser H.; Weber B.
Dr. H. Klauser, Abteilung Allgemein Thoraxchirurgie, Krankenhaus Spandau, Lynarstrasse 12, 13587 Berlin Germany

Klinikarzt (KLINIKARTZ) (Germany) 1998, 27/4 (110-115)
CODEN: KLINF ISSN: 0341-2350
DOCUMENT TYPE: Journal; Article
LANGUAGE: GERMAN SUMMARY LANGUAGE: GERMAN; ENGLISH
NUMBER OF REFERENCES: 13

Operative decompression of median nerve is the standard **procedure** in therapy of carpal tunnel syndrome. In respect of cosmetic and functional disturbing scars there is no end in the discussion for the best surgical **procedure** . In the last years **endoscopic** release of the transverse carpal ligament has been established as an alternative in the therapy of carpal tunnel syndrome with careful treatment of the **anatomical** **structures** of the palm. Precise **instruction** and training of the surgeon and consideration of the contraindications is the supposition for the **operative** treatment. So **endoscopic** carpal tunnel release is a safe surgical technique without complications, less postoperative pain, short rehabilitation and earlier return to work. Therefore **endoscopic** **operations** will detach the open **method** as standard **procedure** by therapy of the carpal tunnel syndrome.

MEDICAL DESCRIPTORS:
*carpal tunnel syndrome--surgery--su; *nerve compression--surgery--su; * surgical technique; * **endoscopic** surgery
median nerve; decompression; training; surgeon; postoperative pain; technique; hand; human; article
SECTION HEADINGS:
008 Neurology and Neurosurgery
033 Orthopedic Surgery

Operative decompression of median nerve is the standard **procedure** in therapy of carpal tunnel syndrome. In respect of cosmetic and functional disturbing scars there is no end in the discussion for the best surgical **procedure** . In the last years **endoscopic** release of the transverse carpal ligament has been established as an alternative in the therapy of carpal tunnel syndrome with careful treatment of the **anatomical** **structures** of the palm. Precise **instruction** and training of the surgeon and consideration of the contraindications is the supposition for the **operative** treatment. So **endoscopic** carpal tunnel release is a safe surgical technique without complications, less postoperative pain, short rehabilitation and earlier return to work. Therefore **endoscopic** **operations** will detach the open **method** as standard **procedure** by therapy of the carpal tunnel syndrome.
MEDICAL DESCRIPTORS:
*carpal tunnel syndrome--surgery--su; *nerve compression--surgery--su; * surgical technique; * **endoscopic** surgery

1998

31/5,K/16 **(Item 1 from file: 94)**

DIALOG(R)File 94:JICST-EPlus

01627300 JICST ACCESSION NUMBER: 92A0558001 FILE SEGMENT: JICST-E
The Use of Xylocaine Jelly in the Endoscopic **Ultrasonography.**
IIDA MICHIO (1); SAITO NAOYA (1); TAKESHITA KIMIYA (1); NAGAHAMA TAKESHI (1); WATANUKI SHIGEO (1); ASHIKAWA TOSHIHISA (1); SUNAGAWA MASAKATSU (1); HABU HIROSHI (1); ENDO MITSUO (1)
(1) Tokyo Medical and Dental Univ., Faculty of Medicine
Prog Dig Endosc, **1992** , VOL.40, PAGE.127-129,421, FIG.5, TBL.1, REF.4
JOURNAL NUMBER: S0983BAB ISSN NO: 0389-9403
UNIVERSAL DECIMAL CLASSIFICATION: 616.3-006 616.3-07 615.2.03:616-07
LANGUAGE: Japanese COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Original paper
MEDIA TYPE: Printed Publication
ABSTRACT: In the treatment of esophageal and gastric cancer patients, prediction of the **depth** of cancer invasion is very important in selecting the **operative procedure** . **Endoscopic** ultrasonograhy(EUS) is a new **method** that can directly examine not only the **lesions** present on the mucosal surface but also the submucosal or extrawall **lesions** . However, it is difficult to obtain the whole **tumor image** clearly in **patients** with severe stenosis of the digestive tract through which the **endoscope** (GF-UM3) can not be passed, or when the whole **lesion** can not be immersed in the degassed water. In these cases misdiagnosis might be made in determining the **depth** of cancer invasion. In 10 such cases, EUS was performed injecting xylocaine jelly around the **lesions** using GF-UM3 or miniature ultrasonic probe(MUP) and clear **tumor** images were obtained. Xylocaine jelly is viscous, degassed and penetrable by ultrasound. Because of its high viscosity xylocaine jelly adheres around of the scope and produces clear **tumor** images even with small amount. A large amount of xylocaine may provoke intoxication. Only the base of xylocaine jelly would be preferable for this purpose. (author abst.)
DESCRIPTORS: human(primates); stomach **tumor** ; duodenal neoplasm; esophageal **tumor** ; gastroscopy; esophagoscopy; ultrasonography; image quality; diagnostic drug; **endoscope** ; ultrasonic **endoscope** ; carboxylic acid; aromatic amine; local anesthetic; antiarrhythmic drug; carboxamide
BROADER DESCRIPTORS: stomach disease; gastrointestinal disease; digestive **system** disease; disease; digestive **system tumor** ; **tumor** ; duodenal disease; intestinal disease; intestinal **tumor** ; esophageal disease; digestive diagnosis; diagnosis; **endoscopy** ; diagnostic imaging; ultrasonic test; nondestructive inspection; inspection; image **characteristic** ; **characteristic** ; drug; amine; aromatic compound; central nervous **system** depressant; central nervous **system** drug; nervinum; circulatory drug
CLASSIFICATION CODE(S): GH04000D; GH02000P; GW20020A

The Use of Xylocaine Jelly in the Endoscopic **Ultrasonography.**
, **1992**
ABSTRACT: In the treatment of esophageal and gastric cancer patients, prediction of the **depth** of cancer invasion is very important in selecting the **operative procedure** . **Endoscopic** ultrasonograhy(EUS) is a new **method** that can directly examine not only the **lesions** present on the mucosal surface but also the submucosal or extrawall **lesions** . However, it is difficult to obtain the whole **tumor image** clearly in **patients** with severe stenosis of the digestive tract through which the **endoscope** (GF-UM3) can not be passed, or when the whole **lesion** can not be immersed in the degassed water. In these cases misdiagnosis might be made in determining the **depth** of cancer invasion. In 10 such cases, EUS was performed injecting xylocaine jelly

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...DESCRIPTORS: stomach **tumor** ; ...

...esophageal **tumor** ; ...

... **endoscope** ; ...

...ultrasonic **endoscope** ;

...BROADER DESCRIPTORS: digestive **system** disease...

...digestive **system** **tumor** ; ...

... **tumor** ; ...

...intestinal **tumor** ; ...

... **endoscopy** ; ...

...image **characteristic** ; ...

... **characteristic** ; ...

...central nervous **system** depressant...

...central nervous **system** drug

31/5,K/17 (Item 1 from file: 144)

DIALOG(R)File 144:Pascal

13779683 PASCAL No.: 98-0492917

Transesophageal biopsy **of mediastinal and pulmonary** tumors **by means of** endoscopic **ultrasound guidance. Commentary**

HUENERBEIN M; GHADIMI B M; HAENSCH W; SCHLAG P M; REED C E comment

Charite University Hospital, Robert ROEssle Hospital and Tumor Institute, Humboldt University, Berlin, Germany

Journal: Journal of thoracic and cardiovascular surgery, **1998** , 116 (4) 554-559

ISSN: 0022-5223 CODEN: JTCSAQ Availability: INIST-9747; 354000070385330020

No. of Refs.: 23 ref.

Document Type: P (Serial) ; A (Analytic)

Country of Publication: United States

Language: English

Objective: The aim of this study was to investigate the value of **endoscopic** ultrasound- **guided** **biopsy** for the diagnosis of thoracic **lesions** . **Methods** : Transesophageal ultrasound- **guided** **biopsy** was performed in 29 patients with mediastinal (n = 25) or pulmonary **tumors** (n = 4). A flexible echoendoscope with a 7.5 MHz **curved** array transducer (Pentax FG 32 UA, Hamburg, Germany) and a **biopsy** device with a fine needle (**diameter** 0.8 mm) were used for all examinations. Three patients were excluded from the analysis of the data because a definite diagnosis based on surgery or follow-up was not available. Results: Real-time visualization of the **biopsy** **procedure** with **endoscopic** ultrasound enabled accurate tissue sampling even of small mediastinal **lesions** with a

diameter of less than 1 cm. Diagnostic material was obtained in 23 of the 26 patients (88%). In 3 cases (12%) non-representative **biopsy** material was found in the specimen. The sensitivity and specificity of transesophageal **biopsy** in the diagnosis of malignancy were 89% and 83%, respectively. Histologic analysis of the **biopsy** specimens established malignancy in 17 of 23 patients, whereas benign **lesions** were diagnosed in 6 **patients** . **Endoscopic ultrasound - guided biopsy** confirmed the diagnosis suggested by conventional diagnostic **methods** in 15 of 23 patients (65%), whereas an unsuspected diagnosis was disclosed in 8 patients (35%). The results of the **biopsy** had considerable impact on the therapeutic strategy. None of the patients had complications related to the **procedure** . Conclusions: **Endoscopic** ultrasound- **guided biopsy** provides a new minimally invasive approach to the **biopsy** of **lesions** in the posterior mediastinum and may complement surgical staging **procedures** .

English Descriptors: Sonography; Technique; Guidance; **Endoscopy** ; Exploration; **Biopsy** ; **Tumor** ; Bronchopulmonary; Mediastinum; Human; Diagnosis; **Pathology** ; **Specificity** ; Sensitivity; Stage classification
Broad Descriptors: Mediastinum disease; Respiratory disease; Lung disease; Bronchus disease; Mediastin pathologie; Appareil respiratoire pathologie; Poumon pathologie; Bronche pathologie; Mediastino patologia; Aparato respiratorio patologia; Pulmon patologia; Bronquio patologia

French Descriptors: Exploration ultrason; Technique; Guidage; **Endoscopie** ; Exploration; **Biopsie** ; Tumeur; Bronchopulmonaire; Mediastin; Homme; Diagnostic; Anatomopathologie; Specificite; Sensibilite; Classification par stade

Classification Codes: 002B24E08

Transesophageal biopsy **of mediastinal and pulmonary** tumors **by means of** endoscopic **ultrasound guidance. Commentary**
1998

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English Descriptors: Sonography; Technique; Guidance; **Endoscopy** ; Exploration; **Biopsy** ; **Tumor** ; Bronchopulmonary; Mediastinum; Human; Diagnosis; **Pathology** ; **Specificity** ; Sensitivity; Stage classification

French Descriptors: Exploration ultrason; Technique; Guidage; **Endoscopie** ; Exploration; **Biopsie** ; Tumeur; Bronchopulmonaire; Mediastin; Homme; Diagnostic; Anatomopathologie; Specificite; Sensibilite; Classification par stade

Spanish Descriptors: Exploracion ultrasonido; Tecnica; Guiado; **Endoscopia** ; Exploracion; **Biopsia** ; **Tumor** ; Broncopulmonar; Mediastino; Hombre; Diagnostico; Anatomia patologica; Especificidad; Sensibilidad; Clasificacion por etapas

31/5,K/18 (Item 1 from file: 95)
DIALOG(R)File 95:TEME-Technology & Management

01190076 I98032136300
Current and future applications of virtual reality for medicine
Satava, RM; Jones, SB
Dept. of Surg., Yale Univ. Sch. of Med., New Haven, CT, USA
Proceedings of the IEEE, v86, n3, pp484-489, **1998**
Document type: journal article Language: English
Record type: Abstract
ISSN: 0018-9219

ABSTRACT:
Virtual reality is just emerging as an accepted scientific discipline for medicine. The majority of near-term applications are in the area of surgical planning, interoperative **navigation** , and surgical simulations. Its use in rehabilitative medicine and psychiatry has made significant progress. The immediate future holds promise for virtual **endoscopy** , which may replace standard **endoscopic** **procedures** for diagnostic screening. Viewing of these **virtual** **images** may be with head-mounted displays or true suspended holograms. The most highly developed area is in surgical simulations. Current generations are approaching photorealistic representation of the anatomy, while measurement science is providing physical tissue properties and physiologic **parameters** . The types of simulations range from "needle-based" **procedures** , such as standard intravenous **insertion** , central venous placement catheter, and chest-tube **insertion** to more sophisticated simulations of full surgical **procedures** like laparoscopic cholecystectomy or hysteroscopic resection of interuterine myoma. In addition, haptic input devices are providing the sense of touch to the **procedures** . Soon there will be patient-specific models derived from computed tomography or magnetic resonance imaging scans that will permit a surgeon to practice a delicate surgical **procedure** on the patient's specific virtual anatomy before actually performing the **procedure** on the patient.

DESCRIPTORS: COMPUTED TOMOGRAPHY; DIGITAL SIMULATION; CONVERSATIONAL TERMINALS; MEDICAL SCIENCE; PHYSIOLOGY; **PLANNING** ; SURGERY; **VIRTUAL** REALITY; PSYCHIATRY; PHYSIOLOGIC **PARAMETERS** ; COMPUTER APPLICATIONS;

MEDICAL IMAGE **PROCESSING**
IDENTIFIERS: MEDIZINISCHE AUSBILDUNG; MAGNETISCHE KERNRESONANZ IN DER MEDIZIN; RECHNERUNTERSTUETZTE SCHULUNG; REALISTISCHES BILD; CHIRURGIEPLANUNG; INTEROPERATIVE **NAVIGATION** ; CHIRURGIESIMULATION; REHABILITATIVE HEILKUNDE; VIRTUELLE ENDOSKOPIE; DIAGNOSTISCHE SCHIRMBILDUNTERSUCHUNG; AM KOPF BEFESTIGTES DISPLAY; Medizinausbildung; Chirurgiesimulation; virtuelle Endoskopie
1998

ABSTRACT:
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DESCRIPTORS: COMPUTED TOMOGRAPHY; DIGITAL SIMULATION; CONVERSATIONAL TERMINALS; MEDICAL SCIENCE; PHYSIOLOGY; **PLANNING** ; SURGERY; **VIRTUAL** REALITY; PSYCHIATRY; PHYSIOLOGIC **PARAMETERS** ; COMPUTER APPLICATIONS; MEDICAL IMAGE **PROCESSING**
IDENTIFIERS: MEDIZINISCHE AUSBILDUNG; MAGNETISCHE KERNRESONANZ IN DER MEDIZIN; RECHNERUNTERSTUETZTE SCHULUNG; REALISTISCHES BILD; CHIRURGIEPLANUNG; INTEROPERATIVE **NAVIGATION** ; CHIRURGIESIMULATION; REHABILITATIVE HEILKUNDE; VIRTUELLE ENDOSKOPIE; DIAGNOSTISCHE SCHIRMBILDUNTERSUCHUNG; AM KOPF BEFESTIGTES DISPLAY; Medizinausbildung; Chirurgiesimulation; virtuelle Endoskopie

31/5,K/19 (Item 2 from file: 95)
DIALOG(R)File 95:TEME-Technology & Management

01017903 I96071860362
Virtualized Endoscope System **-an application of virtual reality technology to diagnostic aid**
(Ein Endoskopie- **System** fuer Anwendungen in virtueller Realitaet als Diagnosehilfe)
Mori, K; Urano, A; Hasegawa, J-I; Toriwaki, J-I; Anno, H; Katada, K
Sch. of Eng., Nagoya Univ., Japan
IEICE Transactions on Information and Systems, vE79-D, n6, pp809-819, **1996**
Document type: journal article Language: English
Record type: Abstract
ISSN: 0916-8532

ABSTRACT:
Proposes a new medical image **processing system** called the "Virtualized

Endoscope System (VES)", which can examine the inside of a virtualized human body. The virtualized human body is a 3D digital image which is taken by an instrument such as a X-ray CT scanner or an MRI scanner. VES consists of three modules: (1) imaging, (2) segmentation and reconstruction, and (3) interactive **operation** . The interactive **operation** module has following the major functions: (a) display, (b) measurement, and (c) **manipulation** of the virtualized human body. The user of the **system** can observe both the inside and the outside of a target organ from any point and any **direction** freely, and can perform any necessary measurement concerning **angles** and **lengths** interactively at any time during the observation. VES enables the user to repeatedly observe an area where a real **endoscope** cannot enter without pain, and from any **direction** which the real **endoscope** cannot. We applied this **system** to real 3D X-ray CT images and obtained good results.

DESCRIPTORS: BIOMEDICAL MEASUREMENT; COMPUTED TOMOGRAPHY; CONVERSATIONAL SYSTEMS; IMAGE RECONSTRUCTION; **LENGTH** MEASUREMENT; **ENDOSCOPY** ; CLINICAL DIAGNOSTICS; MEDICAL **IMAGE PROCESSING** ; **VIRTUAL** REALITY; **IMAGE** SEGMENTATION; INTERACTIVE **OPERATION** ; DISPLAYS; **MANIPULATIONS**
IDENTIFIERS: VIRTUALIZED **ENDOSCOPE SYSTEM** ; DIAGNOSTIC AID; MEDICAL **IMAGE PROCESSING SYSTEM** ; **VIRTUALIZED** HUMAN BODY; **IMAGING** ; **ANGLE MEASUREMENT** ; BODY ORGANS; Endoskopie- **System** ; virtuelle Realitaet

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(Ein Endoskopie- **System** fuer Anwendungen in virtueller Realitaet als Diagnosehilfe)
1996
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IDENTIFIERS: VIRTUALIZED **ENDOSCOPE SYSTEM** ; DIAGNOSTIC AID; MEDICAL **IMAGE PROCESSING SYSTEM** ; **VIRTUALIZED** HUMAN BODY; **IMAGING** ; **ANGLE MEASUREMENT** ; BODY ORGANS; Endoskopie- **System** ; virtuelle Realitaet